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F. L. Henkel,

FIRST LINES

OF

PHYSIOLOGY.

BY

ALBERT VON HALLER.

TRANSLATED FROM THE

THIRD LATIN EDITION.

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OF DR. WILLIAM CULLEN.

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I

Haller

ADVERTISEMENT

TO THE EDINBURGH EDITION.

THE correction of this volume for the preſs was undertaken at the deſire of the Publiſhers. Having already undergone three editions, the preſent Editor believed, that a careful peruſal of the proof-ſheets, and attention to the typographical accuracy of the work, would chiefly conſtitute his ſhare in the publication. On collating, however, the laſt edition with the original of HALLER, it appeared, that few ſentences, and ſcarcely one paragraph, conveyed the true meaning of the Author. In many places, the ſenſe was totally miſtaken, ſometimes perverted, and the omiſſions and interpolations were both ſo numerous, and ſo prejudicial to the work, that thoſe who have formed their opinion of the value of HALLER's Firſt Lines, from any tranſlation in the Engliſh language, muſt have formed an opinion of them, highly detrimental to the well deſerved reputation of the Author. In the preſent edition, with much labour, the Editor has endeavoured to correct theſe miſtakes, to ſupply what was omitted, and to expunge the interpolations; in ſhort, to give HALLER's Firſt Lines in Engliſh.

THE very great deviations made by the original Tranſlator from the meaning of the Author, have betrayed the preſent Editor into an oppoſite fault, that of making his edition more literal than perhaps is conſiſtent with the true idiom of the Engliſh language. For this imperfection he has no other apology to offer: but for the omiſſion of Dr. WRISBERG's Notes, one is neceſſary. Of theſe notes, many are excellent; but as moſt of them are literary, ſome controverſial, and others but add a new conjecture upon points not yet underſtood, and, finally, as they do not now fulfil their original intention of ſupplying every diſcovery made in Phyſiology ſince HALLER's time, it was thought proper not to increaſe the ſize and price of the volume by their inſertion.

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FIRST

FIRST LINES

OF

PHYSIOLOGY.

CHAP. I.

FIBRE.—CELLULAR SUBSTANCE.

I. THE moſt ſimple parts of the human body, are either fluid or ſolid. As the fluids are of different kinds, we ſhall conſider each of them in its proper place; and premiſe the hiſtory of the ſolids, which are moſt ſimple, and the true baſis of the body, to the conſideration of the other parts.

II. The ſolid parts of animals and vegetables have this fabric in common; that their elements, as ſeen by the moſt powerful microſcopes, are either fibres, or laminæ, or unorganized gluten.

III. Fibres for the moſt part, reſemble lines of very minute breadth, or rather ſlender cylinders. Their moſt permanent particles are demonſtrated to

be earthy, by combuſtion, or long continued putrefaction.

IV. Theſe earthy particles derive connection and the power of coheſion, not from themſelves, but from interpoſed gluten. We know this from the preceding obſervations, (III.) and the eaſy experiment, in which a burnt hair, whoſe parts hang ſtill together, recovers a certain degree of firmneſs by being dipped in water or oil. Ivory and bones alſo become friable, by the extraction of their gelly. Long expoſure to weather effects a ſimilar change, rendering bones a true earth, abſorbent and bibulous. But even bone, become friable from having its gelly extracted, reacquires its oſſeous hardneſs, when that gelly is reſtored. The more ſimple animals conſiſt entirely of this gluten.

V. Laſtly, the chemical analyſis of bone, and hair, the gelly of bone, ivory, and horn, the nature of our aliments, &c. prove, that this gluten is compoſed of water, incorporated with oil by animal life. Nor does any other kind of gluten unite the parts of animals more ſtrongly, as we ſee in ſize and common glue.

VI. The primary ſimple fibre, ſuch as we rather comprehend from reaſon than ſenſe, is compoſed of earthy particles, adhering longitudinally, and connected by intervening and coheſive gluten.

VII. But the fibres which appear primary to the ſight, are of two kinds. The firſt is linear, whoſe length is conſiderable in proportion to its breadth, and whoſe elementary particles lie in a ſtraight line, and thus generally parallel to thoſe contiguous. We ſee examples of this kind of fibre in bone, moſt eaſily in thoſe of the fœtus, and alſo in tendons, ligaments and muſcles, always recollecting that the eye ſees not the moſt minute fibres, but only the larger ones compoſed of theſe, and ſimilar to them in ſtraightneſs and ſlenderneſs. That the

the ultimate fibres are perfectly ſimilar, we are convinced by the microſcopes of Muys and Leeuwenhoeck, in which the muſcular fibres, even the moſt minute, appear exactly like the larger ones, and perfectly linear.

VIII. The ſecond kind conſiſts of laminæ, in which, a breadth often greater, is conjoined with a ſhorter length. A looſe web of theſe has got the name of Cellular Tunic, though the term Tunic is on many accounts improper.

IX. This cellular ſubſtance is compoſed of an infinite number of ſmall laminæ, which, by their various directions, incloſe ſmall ſpaces and cavities, and join all the parts of the human body, affording an extenſive and firm union, with ſufficient mobility. But in this web there is the greateſt diverſity in the proportion of the ſolids to the cavities; in the breadth and firmneſs of the laminæ; in the nature of the contained liquor, which is either more watery or more oily; and in the admixture of fibres and filaments, of which there is a great quantity in ſome places, as in the coats of the arteries, in others almoſt none, as under the ſkin.

X. Of this cellular ſubſtance when compacted, from the laminæ concreting, and being compreſſed by the action of the incumbent muſcles, diſtending liquid, or other cauſe, broad plates are formed, which are either rectilineal in general, and more properly called Membranes; or convoluted into cylinders and cones, with liquids flowing through their cavities, and denominated Veſſels; or extending round ſome place in a plane parallel to it, get the name of Tunics. That tunics are formed of cellular ſubſtance, is proved in the aorta, ſkin, pericardium, and dura mater, by ocular inſpection, and eſpecially by maceration. The coats of the muſcles, are alſo evidently cellular, and ſimilar to other tunics. The ſame thing is alſo proved from the eaſy change of the dartos, and the nervous

membrane of the inteftines, into cellular fubftance, by inflation; and from the hard and thick membranes formed in encyfted tumors, which are mere productions of cellular texture. In the integuments, being very clofely compacted in continued gradation, it forms the true fkin lying under the epidermis; and being thence continued, it is at laft partly refolved into the fubcutaneous cellular texture filled with fat.

XI. The veffels which colour the tunics are an addition to the cellular fubftance, and in no wife effential to the nature of membrane, but fuperadded to the membrane formed of the cellular fubftance. Between the mefhes of the inteftinal network of veffels, when moft perfectly filled by the Ruyfchian art, white cellular fubftance remains, even then greatly exceeding the bulk of the veffels, although being preternaturally diftended, they occupy a greater fpace. But I do not know any membranes compofed of fibres interwoven with, and decuffating each other; unlefs you confider as fuch the ligamentary or tendinous fibres which are fpread over true membranes.

XII. Cellular fubftance is found in the human body, wherever there is a veffel or mufcular fibre, without exception, as far as I know.

XIII. The other elementary fubftance of the human body, (II.) which cannot be truly called either a fibre or cellular laminæ, is a mere extravafated gluten, concreted, not into fibres, but in the fpaces betwixt them. This is manifeft in the bones, whofe fibres are feen very diftinctly in the fœtus, with veffels running in the intervals between them; fo that the fkull in every part, refembles a comb. This fabric is fo altered in the adult, that the intervals being filled up by fluid, extravafated in the fpaces betwixt the fibres, as happens with the juice of madder, and the edges being

being agglutinated, laminæ are formed. The cartilages ſeem to be ſcarcely any thing elſe than concreted gluten.

XIV. But here the order of nature ſeems to be, that the fibres above mentioned (III.) are all originally formed of this gluten. That the cellular ſubſtance (VII.) is thus formed, appears from thoſe cellular fibres, produced in the thorax from concreted vapour, which joins the ſurface of the lungs to the pleura, and perfectly reſembling the true and natural cellular ſubſtance, even though compacted of inſpiſſated pus. The ſame appears alſo from a compariſon of the fœtus with the adult; for, inſtead of the abundant ſubcutaneous cellular ſubſtance, the fœtus has a mere jelly interpoſed betwixt the ſkin and muſcles, which have already acquired greater firmneſs; from the morbid diſſolution of the membranes of the muſcles into a mere gluten; and from a ſimilar change into glue of the ſkin, tendons, and ligaments of animals, by means of boiling water. Clots of coagulated blood; the ſanguineous membranes of Ruyſch; Albinus's membranes formed of mucus, polypus, ſilk and glue, alſo illuſtrate this theory. Laſtly, that the bony fibres themſelves are formed of compacted gluten, is ſhown from diſeaſes in which the hardeſt bones, by a liquefaction of their gluten, return into cartilage, fleſh, and jelly. Similar changes are made on the bones of fiſhes and other ſubſtances by Papin's digeſter.

XV. It ſeems, then, that an albuminous fluid, with a ſmall portion of earth, firſt concretes into filaments, from ſome preſſure, whoſe cauſes we now paſs over. Theſe by the mutual attraction of coheſion, leaving, however, ſpaces between them, compoſe the cellular texture, after having acquired ſome firmneſs from the cloſeneſs of the earthy particles, which follows the expul-

ſion

ſion of the too aqueous gluten. This ſubſtance, wherever its laminæ are ſubjected to greater preſſure, turns into fibres and tunics; and, laſtly, with unorganized gluten (XIV.) concretes into bone. (XV.) Hence, in general, all parts of the body, from the ſofteſt to the hardeſt, ſeem to differ only in the latter having more of the earthy particles, and theſe more cloſely compacted, with leſs aqueous gluten; while in the ſoft parts there is leſs earth and more gluten.

XVI. The cellular texture is made up of fibres and laminæ (VIII.) which are neither hollow nor vaſcular, although it is coloured by acceſſory veſſels, but ſolid. The following are its chief varieties. In ſome parts it is looſe, and formed of long and diſtant laminæ; in others thin, and compoſed of ſhort fibres. I find it ſhorteſt betwixt the ſclerotica and choroides of the eye, eſpecially of animals, and betwixt the arachnoides and pia mater of the brain. I alſo find it tender, but more conſpicuous, betwixt every two coats of the inteſtines, ſtomach, bladder, and ureters; in the veſicles of the lungs, under the pulp of the glans penis; and between the ſmall kernels of the viſcera and glands. It is compoſed of ſtill longer fibres, where it accompanies the veſſels, under the name of Vagina, through the viſcera, and particularly the liver and lungs; and is vaſtly firmer in the veſſels which go to the head and limbs. Its principal uſe is to bind together the contiguous membranes, veſſels, and fibres, in ſuch a manner as to allow them a due degree of motion. But the cellular ſubſtance, as hitherto deſcribed, hardly ever contains any fat; but is moiſtened by a watery, gelatinous and ſomewhat oily vapour, exhaled from the arteries, and received again into the veins. The truth of this is eaſily demonſtrable from injections of water, iſinglaſs or oil, made in all parts of the body. When this vapour is wanting,

ing, the filaments cohere, and the contiguous membranes are united, with loſs of motion.

XVII. The cellular texture is more lax, and formed of laminæ rather than fibres, where it divides the muſcular fibres, even the moſt minute; where it looſely accompanies and ſuſtains the veſſels; and within the cavities of the bones, where it is compoſed of bony as well as membranous laminæ. That is likewiſe very lax, which, under the ſurface of the body, is every where interpoſed betwixt the muſcles and the ſkin; but the laxeſt of all is that which ſurrounds with very wide cells the genital parts of the male.

XVIII. Into the empty meſhes of this cellular texture (XVII.) there is poured almoſt every where, in the fœtus, firſt a gelly, then a grumous, and laſtly, under the whole ſkin, and in its pits, a clotted fat. This ſubſtance is lighter than water, inſipid, inflammable, becomes ſolid in the cold, is found in greater quantity about the kidneys and in graminivorous animals; in fiſhes, while alive, and probably alſo in man, nearly fluid, though apt to coagulate. In it an acid ſalt, almoſt in the proportion of one-ſixth, is united with oil.

XIX. Through this cellular texture the blood-veſſels run and are divided; from the arterial extremities of which, the fat is depoſited and abſorbed by the venous. The paſſage, from the arteries into the adipoſe cells, is ſo immediate and free, that they muſt open by very large mouths, ſince they admit injected mercury, air, water, ſize, and oil, which is always very ſluggiſh, even in living animals. It is not ſecreted by any long ducts of particular fabric, but tranſudes on all ſides through the whole extent of the artery; inſomuch that, when an artery is filled with water, there is no part of the ſurrounding cellular ſubſtance which is not moiſtened. The warm fat, during the pulſation of the arteries, eaſily finds out the ſame paſſages.

How

How quickly it is collected, appears from the ſpeedy renovation of fatneſs after acute diſeaſes.

XX. But that this fat is abſorbed by the veins, we are taught from the ſudden effects which muſcular exerciſe has in conſuming the fat, more eſpecially of animals in which it abounds; alſo from its conſumption in fevers; from the cure of dropſies, where the water effuſed into the cellular ſubſtance is in a manner abſorbed and thrown out by the inteſtinal tube; and, laſtly, from the venous tranſudation of water and oil, when injected by the ſyringe, obſerved in every part of the body. Are nerves diſtributed upon the adipoſe cells? It is certain they run through this ſubſtance, and every where divide in it, into the minuteſt filaments, ſo that they can no longer be traced by the knife. That they terminate in it, is not probable; for the fat is both inſenſible and unirritable.

XXI. The meſhes betwixt the laminæ of the cellular membrane, are every where open, and unite in forming one continuous cavity throughout the whole body. This appears from the inflation of the ſkin over all the body, which butchers, and likewiſe the ſurgeons of Ethiopia, effect by a ſingle wound; from emphyſema, in which the air received by a wound of the ſkin, being retained, cauſes a ſwelling throughout the whole body; from the paſſage of bodies, put under the ſkin, to a place remote from that at which they entered; from the paſſage of pus, from an inflamed place to remote ulcers; and, finally, from diſeaſes, in which water depoſited in all the cellular ſubſtance of the body, is completely evacuated by a ſingle incision. That none of the cellular texture is excepted, appears from a caſe of emphyſema in which the vitreous body of the eye itſelf was inflated; and from a diſeaſe, in which the gelatinous

gelatinous ſerum of a dropſy was transfuſed even into the cavernous bodies of the penis.

XXII. The great importance of this cellular ſubſtance will be evident to all who conſider, that from it alone proceeds the due firmneſs and ſtability of all the arteries, nerves, and muſcular fibres, and conſequently of all the fleſh and viſcera formed of theſe: but even the figures of the parts, their juſt length, cavities, curvatures, flexures, depend entirely on the cellular membrane, being in ſome places of a laxer, and in others of a denſer fabric: for when divided, every part is lengthened and collapſes. Of this ſubſtance, with veſſels, nerves, muſcular and tendinous fibres, (a great part of which are however formed of it,) all the viſcera, all the muſcles, glands, ligaments and capſules, are compoſed; on it alone, and its different length, tenſion, quantity or proportion, the diverſity of our glands and viſcera depends; and, laſtly, it certainly conſtitutes by far the greateſt part of the body itſelf, if indeed the whole be not formed of cellular filaments of this kind.

XXIII. It poſſeſſes a contractile power, different from irritability, which, though not demonſtrable by experiments, diſpoſes the cellular fibre to ſhorten itſelf, though for the moſt part ſlowly, after having been ſtretched. This power, excited by cold, renders the ſkin rigid; raiſes the hairs; draws up the ſcrotum; and, after geſtation, reſtores the ſkin of the abdomen, and the uterus, to their former ſize. The ſame force, by a gentle but continual contraction, promotes the ſecretion of fat of the liquors of the ſubcutaneous and other glands, and of pus: in the veins and receptacles, it reſiſts dilatation; and, when that is taken off, it regains its former ſhortneſs. In the fœtus, this gentle force is among the principal cauſes of the changes that happen to the body.

xxiv. The uſes of the fat are various: it every where facilitates the motions of the muſcles, leſſens their attrition, and prevents rigidity: it fills up the ſpaces between the muſcles, and the cavities about many of the viſcera, in ſuch a manner, that it readily yields to their motions, and yet ſupports them when at reſt: it principally conſtitutes the weight of the body; conducts and defends the veſſels: it uniformly diſtends the ſkin; ſerves as a cuſhion to the body, and renders the whole comely: it probably, by mixing with ſome humours, abates their acrimony: it has a principal ſhare in forming the bile; and, by tranſuding through the cartilaginous incruſtations of the bones, it mixes with the articular liquid, and by abſorption, it lubricates their fibres: by exhaling through the pores of the ſkin, it reſiſts the drying ſharpneſs of the air; alſo, by exhaling in a living perſon from the meſentery, meſocolon, omentum, and round the kidneys, it lubricates the ſurfaces of the viſcera with a bland vapour; and, by being interpoſed, prevents their concretion.

xxv. The fat is depoſited into the cells during ſleep, reſt of body and mind, and diminiſhed force of circulation. When collected in too great a quantity, it proves injurious; by compreſſing the veins; and, impeding the action of the heart, it produces aſthma, apoplexy and dropſy. The ſame humour is taken up by the veins; and, being more rapidly moved along the arteries, by violent exerciſe, venery, watchings, cares of the mind, ſalivation, diarrhœa, fever, faſting, it is carried beyond the excretory pores: it is conſumed by ſuppuration. When reſtored to the blood, it increaſes acute diſeaſes, tinges the urine, and forms a part of its ſediment. After being ſuddenly conſumed, it is ſoon renewed again from healthy humours: but, in a languid habit, a gelly, inſtead of fat, is depoſited into the cells, cauſing anaſarca, and external hydrocele.

CHAP.

CHAP. II.

VESSELS.

xxvi. THE membranes will be better defcribed fingly. There are many things common to the arteries. They are long extended cones, decreafing according to the number of their branches. But where arteries run for fome length, without fending off large branches, their convergency is not very evident, if any; and at length, where they are called capillaries, and wherever they give paffage to a fingle globule, they are either cylindrical, or diminifh very imperceptibly; their tranfverfe fections are every where and without exception circular, when the artery is full. Where they fend off large branches, the caliber is fuddenly diminifhed, infomuch that they may be reckoned a chain of cylinders, of which every one is narrower than the preceding. If you reckon them cones, then the bafis of the cone, common to all the arteries is in one or other of the ventricles of the heart; and the apex of the cone, either in the beginning of a vein, or in the beginning of the cylindrical part of the artery, or unlefs it is cylindrical, in an exhaling veffel. In fome places they feem to dilate; at leaft they certainly become wider, after they have been filled and diftended with wax; poffibly from fome obftruction which caufes the injected wax to diftend that part of the artery more than the reft. Examples of this kind we have in the vertebral artery, at the bafis of the fkull; in the fplenic; in the flexure of the carotid, according to Mr. Cowper's injections; and, laftly, unlefs I be much deceived, in the fpermatic arteries. In all places, likewife, where the ramifications begin, the diameter of the artery is a little increafed.

XXVII.

XXVII. There is no external coat proper and common to all arteries. They derive an external and merely incumbent integument, in the thorax from the pleura, and in the abdomen from the peritonæum. In the neck, arm, and thigh, a ſort of thicker cellular ſubſtance ſurrounds the arteries. The membrane of the pericardium, which on all ſides encircles the aorta, returns back with the veſſels to the heart. The dura mater imparts a capſule to the carotid, as it paſſes out of the ſkull. But the firſt true membrane of the arterial tube, is every where cellular, and ſometimes adipoſe as in the thorax.

XXVIII. The external ſurface of this cellular coat is of a looſer texture, coloured by a great many ſmall veins and arteries, and permeated by nerves not very minute. It is ſometimes ſo abundant, that its external layers ſeem hardly to belong to the artery, but appear like an extraneous texture added to it. It is of this appearance in the neck, and round the inguinal, ſubclavian, meſenteric, cœliac, and hepatic arteries, being chiefly compoſed of long filaments. Theſe are the Vaginæ of the Arteries, of ſome eminent men.

XXIX. As this cellular coat advances more inwardly, and nearer to the cavity of the artery, it becomes more denſe, ſolid, and fibrous, and may be called a proper coat of the artery. That there is no tendinous coat of the arteries diſtinct from this cellular ſubſtance, is evident from maceration, by which the inmoſt ſtratum of this arterial tunic becomes cellular.

XXX. Within the former, and nearer the cavity of the artery, we find fibres, in general orbicular; recollecting, however, that no fibre any where makes a complete circle; but that many of them conjoined, with their extremities turned off ſideways, ſeem to form one ring. Theſe fibres, in the larger trunks, form many ſtrata, ſufficiently apparent from

their

their reddiſh colour and ſolidity; but in the ſmaller arteries they are by degrees more difficult to demonſtrate, and ſeem to be wanting in the arteries of ſmall animals. I have never obſerved them longitudinal. Under this membrane, but more difficult to demonſtrate, is an exceedingly ſhort cellular texture, into which the tophaceous matter is poured when an artery oſſifies.

xxxi. The innermoſt coat of the artery is thin, and finely poliſhed by the current of blood; it covers with an uninterrupted lining the fleſhy fibres, which are not ſufficiently continuous, and prevents the blood from inſinuating itſelf into the intervals. It is every where ſmooth and without valves; although, from a ſort of mechanical neceſſity, ſometimes certain folds, raiſed into a ſemicircle at the origin of branches, project, as we ſee, at the branches ſent off from the arch of the aorta. Yet, in arteries of the viſcera, the innermoſt coat is ſofter, lax, wrinkled, and almoſt friable, eſpecially in the ductus arterioſus.

xxxii. The arteries themſelves have arteries, particularly in their external cellular coat, ſpringing on all ſides from the adjacent ſmall arteries, numerous, branchy, reticular, all very minute, even in the fœtus, without injection, very numerous. Nerves every where deſcend, for a great way along the ſurface of the arteries, and vaniſh in the cellular ſubſtance; of which we have examples in the external and internal carotids, and arch of the aorta. From theſe, do not the arteries derive a contractile ſpaſtic force, different from ſimple elaſticity? Do not fevers, faintings, palſy with atrophy, and the paſſions of the mind, prove ſomething like this? But arteries are inſenſible and unirritable; and if they are conſtricted by poiſons, they have that property in common with the dead ſkin.

xxxiii. The ſections of arteries are circular, becauſe they are elaſtic; this is the reaſon why, even from

from the ſmall arteries of the teeth, hæmorrhages are ſometimes fatal. The aorta, indeed, in the thorax and abdomen, the carotids in the neck, and ſome other arteries of the dead body, when not diſtended, appear flat; but their round figure, and circular ſection, are always reſtored by injection. By their elaſticity, arteries ſtrongly compreſs the finger that dilates them, and more tightly in the dead than in the living body. In the living body, indeed, it yields to the action of the heart; but when the heart is relaxed, inſtantly contracts, and regains its former diameter; this conſtitutes the pulſe, whoſe full explication will properly follow the hiſtory of the heart; at preſent, it is ſufficient to ſay, that all arteries pulſate, although the ſyſtole and diaſtole can be perceived by the finger, only in the larger, not in the ſmaller ones; and though in the ultimate inflections of the arteries, it almoſt vaniſhes; for, by an increaſed motion of the blood, even the ſmaller arteries beat violently, as we ſee in inflammations. They contract lengthwiſe ſtrongly, and are rendered ſhorter when cut entirely acroſs.

XXXIV. The ſtrength of the arteries is conſiderable enough: but the denſe, hard texture of the outer cellular coat, as it refuſes to yield to a diſtending force, breaks without much difficulty, almoſt more eaſily than the coats of the veins; hence ariſe aneuriſms. The trunks are almoſt every where weaker, and the branches ſtronger, ſo that the impulſe of the blood may have conſiderable effect upon the former, while in the limbs it has very little. Hence, aneuriſms, are moſt frequent near the heart. In the lower extremities, the ſtrength of the arteries, and of the veins, is increaſed, as well as in the ſecreting organs.

XXXV. Nature has diſtributed arteries over the whole animal body, excepting a few membranes, where they have not yet been demonſtrated. But ſhe

ſhe has diſpoſed of the trunks every where in places of ſafety, becauſe wounds cannot happen to the ſmall ones without danger, or to the large ones without loſs of life. The ſkin has numerous ſhort and ſmall twigs; but the larger trunks, defended by the ſkin and muſcles, creep near the bones. In general, the arteries are in proportion to the parts of the body to which they are ſent, yet larger branches go to the ſecretory organs, ſpleen and brain; and ſmaller ones to the muſcular parts.

xxxvi. The proportion of the ſolid part of an artery to its cavity, is not every where the ſame, nor is it conſtant even in the ſame artery. This proportion, in the firſt place, is leaſt of all at the heart, and increaſes as the arteries remove farther from it. Secondly, in a full fed plethoric animal, whoſe blood paſſes freely, and with great force, through its arteries, the proportion of the ſolid part is leſs than in a famiſhed extenuated creature, whoſe blood moves feebly.

xxxvii. From each arterial trunk, branches are ſent forth, and from theſe again proceed ſmaller ramifications by repeated diviſions, of which you will ſcarcely find the end, though you may, perhaps, trace a ſeries of twenty. The calibers of any two branches taken together, always exceed that of the trunk from whence they come, in nearly a ſeſquilateral proportion, or ſomewhat leſs. In the capillaries this law does not obtain, and the ſum of the calibers of the branches, does not exceed that of the trunk. The ſmalleſt arteries which tranſmit a ſingle globule, have nearly the ſame diameter with a globule, that is, the three thouſandth part of an inch. Every trunk, above its diviſion, expands a little. The angles, at which the branches go out, are generally acute, either half right angles or nearly ſo; which angle, even in mechanics, carries projectiles fartheſt. Inſtances of their going off at right angles,

or

or nearly ſo, we have in the lumbar and intercoſtal arteries; of a retrogade courſe, we have one inſtance in the coronaries of the heart, and another in the ſpinal arteries, which are produced by the vertebrals, and ſeveral in thoſe of the limbs, as in the tibial and brachial. But moſt of thoſe which are eſteemed retrograde, are ſent off, at their origin, at acute angles; ſuch as the aſcending artery of the pharynx, the deſcending one of the palate, the umbilical and mammary arteries, and the nutritious ones of the large bones. Beſides, it is common for larger branches to ariſe under leſs angles, and ſmaller ones under greater angles. It is rare that two arteries of a large diameter run together into one trunk. An example of this, however, exiſts in the artery formed of the vertebrals. In the ſmaller ones it is frequent, as in both the ſpinal arteries, and that of the ſincipital foramen. In many parts, they have repeated flexures, ſo that the artery undulates around a ſtraight line, in alternate obtuſe angles. This happens moſt frequently wherever the diameter of the part to which the artery goes, is occaſionally much increaſed, as in the large inteſtines, womb, face, ſpleen, lips, and iris. Even the ſtraight arteries in other places, if too much diſtended; fall into ſerpentine flexures. Sometimes they are ſuddenly twiſted into a kind of circle, as the carotids under the mammillary proceſs.

xxxviii. They are frequently conjoined by intermediate branches, in ſuch a manner, that the twig of one artery ſhall run to meet one of the ſame kind, from a neighbouring artery, and unite with it into one trunk. We find inſtances of this, in large trunks in the inteſtines, among the middling ones in the kidneys, womb, &c. and among the ſmaller ones in all parts of the body; ſo that there is no part of the human body, in which the neighbouring arterial branches; whether

whether of the ſame or of different denominations, are not joined by intermediate branches. Of circles formed by arteries diverging laterally, and uniting again with each other, we have inſtances in the eye and brain. The extremeties of the arteries which are either cylindrical or nearly ſo, ſend off ſmaller branches, which, in the ſame extent, are more numerous, and are generally reticular; ſo that each branch, by its ſmaller twigs, forms anaſtomoſes with thoſe of its neighbouring branches: and thus we find it in all membranes. By this means it happens, that, though the paſſage from the heart to any part of an artery be obſtructed, the blood may nevertheleſs flow through the neighbouring arteries into all the branches of the obſtructed one. Thus, gangrene and langour are very powerfully prevented, and obſtructions are more eaſily reſolved by the repulſion of the obſtacles into the larger part of the trunk.

XXXIX. Laſtly, the minute arteries terminate in veins, either by a continuation of their canals, ſo that the ultimate little artery, which is generally reflected, having paſſed the angle of its reflection, has now become a ſmall vein; or elſe a branch, ſent out at right angles from the artery, is inſerted under a like angle into the branch of a ſmall vein. Both theſe kinds of mechaniſm are demonſtrated to us by the microſcope, and by the eaſy return through the veins, of injections thrown into the arteries. Theſe veſſels are ſometimes large enough to receive ſeveral globules, and ſometimes admit only one. A large artery never terminates in a vein.

XL. In the viſcera we do not find their diſtribution ſo truly reticular but varied, the ſmall branches deſcending, crowded together, bruſhy, arbuſcular, parallel to the trunk, ſerpentine or villous, according to the various natures of the parts.

XLI. Sometimes the arteries end in another manner, namely, by being converted into veſſels of ſmall-

er orders. Theſe are ſometimes continuous with the arteries and are real trunks, as in the ophthalmic artery, if you examine the arteries of the tunica choroides, then the circle of the uvea, and laſtly, the colourleſs ones of the iris. That a network of pellucid arteries is continuous with the red branches in the tunica conjunctiva, is evident from inflammation, and the redneſs of the part when relaxed by vapour, or by cupping, from injection, and the microſcopical obſervations of Lieberkuhn upon frogs, in which colourleſs globules were ſeen to paſs from red arteries into lateral veſſels. In a fabric of this kind, the red blood is eaſily forced into the ſmaller veſſels.

xlii. In other places the ſmaller veſſels ſeem to proceed laterally from the trunks of the leaſt ſanguiferous arteries, as branches ſmaller than the trunks. Theſe are called Excretory Ducts. It is with difficulty that theſe are filled through the red veſſels; of this we have, however, examples in the kidneys, the liver, and breaſts. And the blood, when vitiated, penetrates the excretory ducts of the whole body without hurting the veſſels, ſince that aberration has no bad conſequence.

xliii. Another termination of arteries is in exhaling veſſels; and this is frequent in all parts of the body. The whole ſkin, all the membranes of the human body which incloſe any cavity, all the ventricles of the brain, both chambers of the eye, all the adipoſe cells and pulmonary veſicles, the whole cavity of the ſtomach and inteſtinal tube and air paſſages, are all of them repleniſhed with exhaling arteries of this kind. Theſe emit a thin, watery, gelatinous humour, which, by ſtagnation, congeſtion, and accumulation, from diſeaſe or death, is converted into a watery, but coagulable lymph. The truth of this is eaſily demonſtrable from the exudation that enſues from injecting the arteries with warm water. In ſome places, indeed,

deed, they pour out, not a thin vapour, but blood itſelf, as we ſee in the heart, the cells of the penis, urethra, clitoris, and nipple of the female breaſt; in all which the blood itſelf is poured out in its natural ſtate. Is not every ſecretion in true glands or cryptæ, analogous to this exhaling fabric?

XLIV. In every part of the human body, do veſſels ariſing from the ſanguiferous ones, but carrying a humour thinner than blood, again ſend out other ſmaller veſſels, to be ſubdivided into ſtill leſs orders? We ſeem, indeed, not to want examples of this, as pointed out by men of eminence. That the aqueous humour is ſecreted by minute veſſels, generated from the colourleſs arteries of the iris, is very probable. That the red coloured veſſels in the cortical ſubſtance of the brain, by the intervention of another order of veſſels, ſeparate a juice pervading the medullary ſubſtance, is almoſt certain. Eryſipelas, and the yellow inflammation, ariſing from the yellow or ſerous globules impacted into ſmaller veſſels, ſuggeſt the ſame opinion.

XLV. Are there then yellow arterial veſſels of a ſecond order, which ſend off lymphatic ones of a third, from whence, by degrees, ſtill leſs kinds of veſſels branch out? Such a fabric does not ſeem agreeable to the eaſy tranſition of blood, mercury, or wax, into the exhaling, perſpirative, uriniferous and adipoſe veſſels and pulmonary cells; nor is it very difficult for the blood to ſtray into the lactiferous, lymphatic, and lachrymal veſſels, whither it ſhould ſeem not able to penetrate, if it went through any other intermediate vaſcular ſyſtem, ſmaller than the blood-globules. Nor is this opinion admiſſible, from the great retardation which muſt ariſe to the humours in a third, and much more in inferior orders of veſſels.

XLVI. The VEINS, in many particulars, reſemble the arteries. There are ſix, of which two anſwer to the aorta, and the remaining four to the

 pulmonary

pulmonary artery. Their basis is in the ventricles of the heart, and their apices in the extremity of each branch, through all parts of the body, excepting one instance, in the liver. In most parts, they run parallel with the arteries, contiguous to them; but they differ in various respects.

XLVII. The fabric of the veins is thin, every where smooth, difficultly separable into membranes; of which the inmost is like that of the arteries, and round it is a condensed, but very easily distended, cellular membrane, surrounded in a single instance, above and below the heart, with transverse muscular fibres. The cellular substance, which connects them to the rest of the body, is, however, like that of the arteries, every where very lax. Notwithstanding this slender fabric, the veins are every where sufficiently firm, and do not easily burst when inflated with air; being, in most instances, stronger than the arteries themselves. But they burst more easily in man while alive, as appears from morbid instances in the leg, arm, face, &c. Nor do they support themselves after being divided, but collapse so as to make their apertures appear like slits; unless they be prevented by some strong cellular substance placed round them, as we see in the liver and womb. They are moderately irritable, and not by stimuli alone, unless they be chemical; but, in that case, they contract more than the arteries. They have no pulsation, unless, if we may trust all accounts, when the venous channel is somewhere obstructed; or when, in dying people, the blood is thrown back again from the right auricle into the descending and ascending cava, or falls back from the brain.

XLVIII. The veins are much larger than their corresponding arteries, having the square of their diameter often double or triple that of the latter; and sometimes almost quadruple, as near the root of, and in the vessels of the kidneys. In general, however, the

the diameter of the veins is to that of the arteries as nine to four; yet the capacity of the capillary veins but little exceeds that of the arteries which accompany them. They differ likewife from the arteries in their divifion, having more numerous trunks and branches; for to one artery in the limbs we ufually meet with two veins. The larger veins are alfo more reticulated, and unite by more frequent anaftomofes, not only of the fmall branches, but even of the large trunks, occurring every where amongft the neighbouring veins, upper with lower, and right with left. They prefer the furface of the body; and through the limbs, neck, and head, they run a long way, perfectly cutaneous, which is very rarely the cafe with arteries; from which, on that account, they feparate. Then the veins follow the furface, without a correfponding artery, which, in the mean time, runs at a confiderable depth, attended by fome fmaller venous branch. In the fmaller branches, and membranous reticulations, and in the internal fabric of the vifcera, the veins and arteries commonly run contiguous. The veins are generally lefs tortuous.

XLIX. In the larger fanguiferous veins, valves are found in great numbers. The innermoft membrane rifes double into the cavity of the vein, in the manner of a curtain, and being on either fide extended deeper along the courfe of the vein, forms what may be called its cornicles: but the bafis, where it arifes from the vein in the fhape of a fegment of a circle, is ftronger, and conftitutes its agger. With the fides of the vein as it proceeds, they inclofe a curtained fpace, of which the exterior fide is the vein itfelf, and the interior the valve, which by its convexity projects into the cavity of the vein. The bafis of this almoft parabolic fpace, or the mouth of the valvular cavity of the veins, always looks towards the heart. They

are

are found in all the ſubcutaneous veins of the limbs, in thoſe of the neck, face, tongue, and in the veins of the penis : at the origin of the larger branches, there are two, three, four, and ſometimes five of them together, which, however, is rare : in the ſmaller branches they are ſingle. There are none in the veins of the deep ſeated viſcera; and, therefore, none in the brain, lungs, heart, or liver, or in the whole ſyſtem of the vena portarum, or in the kidneys or womb, (except one or two valves in the ſpermatic vein;) or, laſtly, in thoſe ſmaller veins, which are leſs than a line in diameter. Sometimes, though rarely, they have been ſeen in the vena azygos. In the cava, at the mouths of the hepatic and renal veins, I have obſerved a ſort of wrinkles in their place. In the ſmaller branches, the ſolitary valves are long and very acutely parabolical, almoſt proportionately longer as the vein is ſmaller. Theſe ſeem to oppoſe the reflux of the blood more powerfully than the larger ones.

L. The origin of the veins we noticed in ſpeaking of the arteries. They ariſe continuous from minute arteries, by inſerted branches, or the reflection of a trunk. Others, again, are either continued from veins of inferior orders, or receive additions and roots from them ; as, for inſtance, in the lymphatic veſſels and thoracic duct. Others of a bibulous kind take their origin from the abſorbing veins diſperſed over the whole body, in the cavities of the eyes, inteſtines, breaſt, peritonæum, pericardium, and ventricles of the brain. Hence the venous exudation, eaſily imitable over the whole human body, by injecting the venous trunks with an aqueous liquor ; hence water, jelly, or oil, paſs from the vena portarum into the cavity of the inteſtines ; hence water, injected into the abdomen of a living animal, quickly diſappears. But of theſe

things

things we ſhall ſpeak again more fully in their proper places.

LI. Little different are thoſe veins which ariſe from every part of the cellular membrane, and carry back to the maſs of blood, dropſical waters, moiſt vapours, diſſolved fat, extravaſated and corrupting blood, and the poiſon of opium introduced into the cellular texture; or bring back the blood itſelf from the cellular fabric of the penis, clitoris, or nipples of the breaſts, after the venereal orgaſm. That, into all the glands, veins of this kind open, is highly probable, which, by abſorbing the thinner humour, leave the remaining maſs of a thicker conſiſtence, as, for example, the bile, ſperm, mucus, &c.

LII. That there are ſmaller orders of veins, as of arteries, reſembling thoſe which convey blood, appears from experiments. Thus, in the eye there are the ſmall veins of the iris, and not a few trunks in the adnata; and, without doubt, veins return from the vitreous humour, which, in health, are pellucid.

LIII. But, in moſt parts of the human body, other veins are found, full of a reddiſh, yellowiſh, or almoſt pellucid liquor, coagulable by heat; formed of a very tender coat, and excitable by chemical ſtimuli. They are intercepted by double valves, for the moſt part ſo very frequently, that they almoſt ſeem jointed when they are turgid. By degrees uniting, either the whole or greateſt part of them meet in the thoracic duct. They ariſe from the cellular texture throughout the whole body, as I had long ago learned of the lactiferous veſſels of the breaſts, the vaſa efferentia of the teſticles, and, laſtly, of the lymphatics originating from the meſenteric glands; and is now ſhewn of the lymphatic veſſels of the teſticles, ſpleen, and other parts. From analogy, and from the analogy of diſeaſes, eſpecially of dropſy, we are induced to believe, that they ariſe likewiſe

wise from the large cavities of the body; nor is it contradictory to suppose, that this kind of vessels receive a thin humour from very minute veins. But all the lymphatics, in their course, meet with a peculiar kind of glands, called Conglobate, into which they enter, having become arterial by the convergence of the venous cones, and dividing into branches; and again issue from them, to unite into new trunks.

LIV. These glands themselves consist of lymphatic vessels, connected by cellular texture, into which a fluid brought by the arteries, exsudes, and from which it is taken up by the vessels which carry away the lymph. They are covered with a continuous membrane, generally of an oval shape, whether they are simple or compound; and they follow the course of the larger blood-vessels; especially of the veins, through the whole trunk of the body, to the insertions of the limbs; running along the jugular and subclavian veins, the vena cava superior, the aspera arteria, gullet, lumbal vena cava, vena porta, the iliac, hypogastric, crural and popliteal veins, and likewise the vessels of the stomach, spleen, mesentery, and mesocolon.

LV. They are found on the surface of the viscera, in the thorax and abdomen; and more easily in brutes: in the lower part of the face, muscles of the tongue and parts adjacent, in the neck, and those parts of the upper limbs which are nearest the trunk, as far as the bending of the elbow; throughout the whole length of the anterior and posterior mediastinum, and wherever we find conglobate glandules, either in the neck or thorax; in the whole lumbal region that is contiguous to the aorta; in the mesocolon, pelvis, vessels and surface of the testicle; and in the lower limbs, wherever they are supplied with conglobate glandules, as far as the knees. Whether they extend further, and exist in every part of the body, in the brain, eye, hand, foot,

foot, back, fore part of the peritonæum, &c. is not confirmed by ſufficiently accurate or numerous obſervations on the human body. They are every where found on the ſurfaces of the viſcera. They are almoſt every where collected into bundles, which lie not far from the large blood-veſſels. Thoſe from the inferior limbs, pelvis, and loins, run into one duct, which is joined by another bundle coming from the liver, ſpleen, and ſtomach; and that trunk, at length, becomes the thoracic duct. The ſuperior veſſels, from the whole extent of the breaſt, the head, and ſuperior limbs, empty themſelves into the ſame duct towards its upper extremity. They ſeem, however, likewiſe to terminate in the red veins.

LVI. Of what ſervice theſe glands are to the lymphatic veſſels is not yet well known. In the fœtus, as well as the thymus and glandulæ renales, they are turgid with a milky liquor; but it is not certain that this fluid is poured out into the cellular ſpaces. It is however rendered probable by late experiments, that in theſe glands ſome kind of fluid is prepared which is mixed with the lymph; ſince thin fluids, injected into the arteris, enter the lymphatic veſſels. In the progreſs of life, this fluid vaniſhes; and the glands themſelves, being dried up, almoſt diſappear. The very frequent ſchirroſities in theſe glands ſeem to indicate, that the motion of the fluid paſſing through them is retarded.

LVII. Their valves (LIII.) are compoſed of two ſemicircular membranes, which give way to the fluid that goes toward the larger trunks; and by applying themſelves to the ſides of the veſſel, leave a free paſſage. But the ſame valves, if the liquor return from a larger trunk towards the ſmaller branches, being filled, ſwell, expand, and ſhut up the tube.

CHAP.

CHAP. III.

OF THE CIRCULATION OR MOTION OF THE BLOOD THROUGH THE ARTERIES AND VEINS.

LVIII. THE arteries and veins hitherto defcribed, contain either blood or lymph. The red blood, whofe nature we fhall explain when we treat of fecretion, fills the arteries and veins commonly known, which we call red, or thofe of the firft order, and which have their origin in the heart. Thefe it fills, in a living perfon, in fuch a manner that at one time they are very loofely and imperfectly diftended by it, and at another, they are rendered very full and turgid. After death, the veins are found very full of blood; but occafionally, the fmall veins, chiefly fome time after death, have been found diftended with air. The arteries in the dead body, commonly contain only a fmall quantity of blood.

LIX. This blood is rapidly moved through all the veffels of the living body. The truth of which is demonftrated by wounds, from which, even a mortal lofs of as much blood as is neceffary for the maintenance of life quickly enfues, almoft inftantly from the larger arteries, and fometimes very fuddenly from the fmaller ones, but more difficultly from the veins, unlefs very large; yet are there not wanting inftances of fatal hemorrhages from wounds of the vein in the inner corner of the eye, or of that under the tongue. Laftly, experiments made upon living animals, fufficiently prove the powerful impulfe with which the blood is moved, particularly through the arteries. In the large arteries it runs moft fwiftly; in the fmall ones, fomewhat flower. In the large veins, the blood moves more flowly than in the arteries, in the fame proportion as the calibers of the arteries are lefs than thofe of the

the veins, almoſt twice or thrice. Another argument is derived from the compreſſion and relaxation of a vein, by which the motion of the blood is promoted from valve to valve. This motion in the veins, is equable enough; but, in the arteries, it is alternately greater, ſo that the veſſel at one inſtant rebounds ſtrongly, and at the next is relaxed. This is confirmed in living animals by ocular inſpection.

LX. The direction of the motion of the blood through the red veſſels, is ſhewn by experiments of this kind. Firſt, it is certain, that all the arteries and veins communicate; becauſe, from one, and often a ſmall artery, and ſometimes alſo from a vein, all the blood ſhall be diſcharged, even cauſing death and extreme pallidity of the whole fleſh, not only of the limb wounded, but of the whole body. Fatal examples have occurred from arteries of the noſtrils, gums, fingers, teeth, from a cutaneous pore, lachrymal point, cupping, and the bite of a leech. There muſt therefore be paſſages by which the blood ſpeedily flows from the venous into the arterial ſyſtem.

LXI. That the blood, again, in the arteries, flows from the heart toward the extreme parts of the body, is proved by the microſcope, and by tying up the artery of a living animal. For if an artery be ſtopped by a ligature, a ſwelling enſues in that part betwixt the heart and the ligature, whilſt the other part beyond the ligature, and more remote from the heart, becomes empty, has no pulſation, nor, if wounded, bleeds. The effect of a ligature is alſo produced by diſeaſe; as when ſome tumor, by compreſſion, or an aneuriſm, intercepts the motion of the heart. Experiments have been made on moſt of the arteries even by myſelf. Sometimes anaſtomoſes, or the eſcape of the blood by ſome channel into a neighbouring branch, and the retroceſſion of the blood in a dying animal, ſeem exceptions.

LXII.

LXII. There have been doubts with regard to the motion of the venous blood, and all the ancients were perſuaded, that the blood flowed alſo in the veins from the heart, or certainly from the liver, to all parts of the body. Few have diſcovered the error: ſeveral, indeed, in the pulmonary vein: in the vena cava, fewer; perhaps only Andreas Cæſalpinus, and as an uncommon appearance, Veſalius.

LXIII. Harvey firſt eſtabliſhed, by experiments, the courſe of the venous blood which returns from every part to the heart, ſo as to remove every doubt. And, firſt, the valves point out this truth; for the common office of theſe valves is, that every preſſure, however applied to the veins, determines the blood towards the heart, ſince they take away the poſſibility of its returning into the branches, after having once entered a trunk. For, ſince the valvular portions are concave upwards, towards the heart, the refluent blood enters into and expands them. Thus, that part of the valve which projects looſely within the cavity of the vein, approaches towards the axis, until it meet the oppoſite ſide, and ſhut up the tube. This we know from inflation, ligatures, and injections; for we never can force a liquor eaſily into the veins againſt the valves. They do not, indeed, every where ſhut up the cavity entirely; but they always do it in a great meaſure.

LXIV. Another office of the valves in the veins ſeems to be to ſuſtain the weight of the blood, that its upper columns may not gravitate upon the lower, nor the blood, flowing through the trunks, impede that coming through the branches. For if, from the ſlower motion of the blood, it ſhall happen that its weight ſhall bear too great a proportion to the impulſive force, and any part of the ſanguineous column begin to deſcend by its weight, the neareſt valve ſupports it in its relapſe, prevents it from preſſing on the ſucceeding column, and affords time

for

for ſome contiguous muſcle, by its preſſure, to free the valve, and propel the column. This is the reaſon for the ſituation of valves in the veins of the limbs and neck; in which parts they are both more numerous and more robuſt than elſewhere. This alſo explains the cauſe of varices, when the blood, enterin the valves, preſſes their ſolid convexity downwards, and forces them to deſcend and dilate. Likewiſe, in muſcular motion, the valves occaſion the whole preſſure which the veins then ſuſtain, to forward the due courſe of the blood towards the heart.

LXV. Moreover, the valves placed in the right ſide of the heart, are ſo conſtructed, as we ſhall hereafter ſee, that they freely permit blood, air, or wax, to paſs from the venous trunks of the cava into the heart, but allow nothing to eſcape from the heart.

LXVI. Beſides, in a living perſon, ligatures make the thing evident. When either by deſign or accident, the veins of the ham, arm, or leg, are tied with the limb itſelf, the limb every where below the ligature ſwells, the veins become diſtended and turgid, and, when opened, freely diſcharge blood; nothing of this kind happens above the ligature, nor are any veins to be ſeen there. The ſame happens when the veins are compreſſed by ſchirrous viſcera, or enlarged glans; and from polypi, tumors of the large veins are frequent. Ligatures retain the blood in any limb round which they are tied, and prevent it from returning to the heart, and from being loſt through a wound in another part.

LXVII. The experiments which have been made on living animals, are ſtill more accurate. From them, even from our own, it appears, that, by tying, in a living animal, any vein, whether belonging to the cava or to the pulmonary veins, that part always ſwells which is moſt remote from the heart, and is diſtended with the blood retained by the obſtacle, while that next the heart becomes pale and flaccid. Laſtly, if both the arteries and veins be tied, the veins

veins collapſe; but, upon removing the ligature, the veins are immediately filled.

LXVIII. In like manner, the injection of poiſons or medicines ſhews, that, into whatever vein you inject chemical acid ſpirits, the blood even to the heart is coagulated by the force of the poiſon. But the affection of the brain by the narcotic power of opium, of the inteſtines by purgatives, and of the ſtomach by emetics, clearly proves that the blood, with which theſe ſubſtances were mixed, had paſſed from the venous branch to the heart, and from thence through the whole body.

LXIX. Moreover, from the transfuſion of blood, it appears that the living blood of one animal, injected into the vein of another, completely emptied of blood, repleniſhes its heart, arteries and veins, ſo as to reſtore vigour, turgidity, and even to produce plethora.

LXX. But that the blood paſſes from the minute arteries into the minute veins, we are taught by injection; filling, without much difficulty, by one arterial trunk, the arteries and veins throughout the whole body, provided the liquor be watery and fluid; and with very great eaſe thoſe of the head, meſentery, heart and lungs.

LXXI. Laſtly, microſcopical obſervations on the pellucid tails, feet and meſenteries, of animals, prove, beyond all doubt, that the blood, carried to the extreme parts by the arteries, is poured either into ſmall veins, continuous with the reflected arteries, or through communicating branches from an arterial trunk into a parallel vein, and that it returns by the veins to the parts nearer the heart. This tranſition happens both in the moſt minute veins, which are capable of receiving only one globule, and in thoſe ſomewhat larger, which admit two globules. That there is no where any ſpongy or parenchymatous ſubſtance interpoſed between the arteries and veins, is proved both by the microſcope

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crofcope and by injections, which, if there were any cellular fpace betwixt the arteries and veins, would be extravafated in fhapelefs maffes.

LXXII. The circulation of the blood, is, therefore, now received as a medical truth by every one; namely, all the blood of the human body is carried through the aorta, from the left cavity of the heart towards the extremities of the arterial branches; whence it is, entirely tranfmitted into the minute veins; from thence it returns to the large veins, the cava and heart itfelf; in which courfe it perpetually circulates.

LXXIII. Yet inftances occur, when, from paffions of the mind, from a fudden great revulfion by blood-letting, or from convulfion, the blood has retroceded from the fmaller into the larger arteries. And, in like manner, from an obftruction being formed in the venous branches above the valves, the blood has been known to return into the extreme branches. But thefe deviations, are, for the moft part, tranfitory, and the blood foon returns into its natural courfe. They may be fuppofed to happen moft frequently in the abdomen and vena portarum.

LXXIV. The courfe of the humours in the valvular lymphatic veins, appears from ligatures and from the valves: for every lymphatic vein when tied, fwells between its fmaller extremities and the thoracic duct; but grows flaccid betwixt the duct and ligature. All the valves, like thofe of the veins, allow air and mercury to flow freely into the thoracic duct; but they refift, and often obftinately, the contrary courfe, although fometimes in the dead body they have given way.

LXXV. The vapour that moiftens the cellular fubftance, the halitus of the abdomen and other cavities are conveyed from the pellucid into the red veins, that thefe may tranfmit their contents to the heart. Hence, when a vein is compreffed or tied, œdema

œdema enſues, the fluid ſtagnating, from its paſſage being interrupted. In the other ſmaller veſſels, experiments cannot be made; but reaſoning and analogy ſupport the ſame concluſion. Experiments concerning the fluid, reabſorbed from the inteſtines, pulmonary veſicles and ſkin, ſhall be mentioned in their proper places.

LXXVI. Therefore all the fluids in the human body are expelled from the heart into the aorta; and except thoſe which are exhaled out of the cavity of the body, or are excreted, they all return to the heart through the minute veins. It remains to diſcover a paſſage by which the blood may return from the right to the left ſide of the heart; but this paſſage ſuppoſes an acquaintance with the hiſtory of the heart and pulmonary veſſels.

CHAP. IV.

HEART.

LXXVII. THE thorax, compoſed of bones and cartilages, on the whole, reſembles a truncated cone, as we ſhall hereafter mention. The lateral parts of this cone, are two membranous bags, having at their upper end an obtuſe termination, above the firſt rib, at which place they are contiguous, and ſeparated only by ſome cellular ſubſtance. Their obliquity is ſuch, that the right bag is wideſt, and adheres to the middle of the ſternum, but as it deſcends it inclines to the left ſide, and comes from the very margin of the ſternum. The left bag deſcends not from the ſternum, but from the cartilages of the ribs. The inner and oppoſite ſides of each bag, form what anatomiſts call the mediaſtinum. Theſe bags have no communication whatever, and the right may be opened and its lung deſtroyed, without injuring the left. But the membrane

membrane which forms them, is ſimple, denſe, externally ſurrounded by cellular ſubſtance, is called the pleura, is harder than the peritonæum eſpecially towards the back, ſofter anteriorly, and is naturally inſenſible. The cavity of the mediaſtinum, or interval between the right and left bags, broadeſt above, but alſo conſiderable below, contains the thymus, conglobate glands, fat, veſſels, and in ſome diſeaſes, pus.

LXXVIII. Below, the ſame bags diverging, recede from each other, and leave a cavity central in all its dimenſions, which ſeparates them. This cavity is the pericardium. But the bags of the pleura, deſcending at the ſides of the pericardium, and before and behind it, terminate finally, about the fifth or ſixth rib, upon the diaphragm, and on it have their baſis, which is truncated obliquely, ſo that anteriorly it is ſhort, but poſteriorly deſcends farther, and is arched upwards. Within theſe bags are the lungs. Poſteriorly, theſe bags are more tender, contiguous and ſeparated in the ſame manner by cellular ſubſtance, which terminates on the pericardium, and includes, in ſome meaſure, the aorta, but more evidently the trachea and œſophagus. This is the poſterior mediaſtinum. Triangular productions of each lamina of the mediaſtinum form the ligaments of the lungs, one on each ſide.

LXXIX. The pericardium, or third bag, which is looſely ſurrounded, firſt by cellular ſubſtance, and then on all ſides by the contiguous pleura, as an exterior lamina, touches the ſternum by a very ſmall part indeed; ſince the lungs when diſtended, cover the heart almoſt wholly before, and interpoſe themſelves betwixt the ſternum, and pericardium below; and the mediaſtinum, by gradually diverging towards the left ſide, has an interval, narrow indeed, under the lower end of the thymus, to each ſide of which, the lungs extend: but this ſituation

is diſturbed, unleſs you are careful in the manner of opening the thorax. The pericardium has a broad, ſomewhat round baſis, adhering to the tendinous, and by a ſmaller part on the left ſide, about the fifth or ſixth rib, to the fleſhy part of the diaphragm ; in young ſubjects by looſe, but in adults by very firm, cellular ſubſtance. Towards the right it is broader, and towards the left it grows ſmaller. It is ſomewhat larger than the heart, that it may move freely in it. It never certainly was wanting.

LXXX. Upwards, the pericardium grows gradually narrower, ending above the heart in an obtuſe conical appendix, which adheres to the coats of the large blood-veſſels almoſt to the upper edge of the ſternum ; firſt to the inferior branch of the right ſuperior pulmonary vein ; then to the vena cava ; after that to the aorta, on its acceſſion to which it is higheſt ; then downwards to the ſame veſſel, and the ductus arterioſus ; hence to the left branch of the pulmonary artery, and at laſt to both branches of the left ſuperior pulmonary vein. On the back part it is again attached to the right pulmonary vein ; then to the left ſinus, to both left pulmonary veins, and to the auricle of the ſame ſide ; then a long way from the pulmonary vein to the inferior cava, then to the ſeptum of the ſinuſes, then to the inferior cava. Beſides, it adheres to the pulmonary artery, its right branch, and the aorta below the origin of its great branches, ſurrounding each artery with a cylindrical production, ſo that it appears like a kind of partition between every two neighbouring veſſels. Thus alſo it contains the vena cava ſuperior in a ring ; and the anterior and poſterior cavities of the pericardium are looſely continued between that vein and the aorta. In like manner it ſurrounds the inferior cava. But this ſheath, by which the veſſels are ſurrounded, preſerves its nature only for a ſhort ſpace, and immediately returns to the heart with thoſe large

veſſels

veſſels which it there ſerves as an external coat. But it ſends cellular ſubſtance like a ſheath, along with the great arteries and veins, to the lungs.

LXXXI. The pericardium has its arteries either from thoſe of the thymus, from thoſe which accompany the phrenic nerve above and below, from the larger phrenic arteries, from the mediaſtinal branches of the mammary, from the bronchial, œſophageal and poſterior mediaſtinal arteries, or from the coronaries which inoſculate with the bronchials and others. The trunks of the veins are analogous, but with more evident anaſtomoſes between thoſe of the right and left ſides. The nerves are from the ſuperficial cardiacs.

LXXXII. The membrane which properly conſtitutes the pericardium, is ſtrong, white, compact, more robuſt than the aorta itſelf, and through its ſubſtance the nerves of the heart and ſome ſmall veſſels deſcend. The ſurrounding cellular ſubſtance makes its outer ſurface ſomewhat rough, while internally, where it is in contact with the heart, it is very ſmooth, and moiſtened on all ſides by a watery vapour. This halitus, which we have always obſerved in the living animal, conſtitutes the water of the pericardium, ſmall in quantity, but always preſent, limpid, or tinged with yellow or red, ſomewhat viſcid, erroneouſly denied by ſome; and in ſome diſeaſes immenſely increaſed. The nature of this fluid is lymphatic, becauſe it thickens into a gelly by heat, and in diſeaſes, mixed with the mucus which every where exudes from the heart and its pericardium, it concretes into villi and cellular ſubſtance. This liquor is ſecreted, without any glands or viſible pores, from the exhaling arteries of the heart, auricles and pericardium; as may be proved by the tranſudation of water or ſize injected into the large arteries.

LXXXIII. The uſe of the pericardium is to contain this vapour, and the heart, ſo that it may have

a fixed point, to which, when in motion, as to a fulcrum, it may draw its fibres, without ſtretching the large veſſels, and that it may not ſhift, pendulous, on changing the poſition of the body. For theſe reaſons, we find it in all animals that have a true heart. A watery vapour bedews the very hot and very rapidly moved heart. It prevents friction, and its coheſion with the pericardium; for, when this vapour is dried up, the pericardium adheres to the heart, either in ſome particular place, or over its whole ſurface, ſo that it may ſeem to be wanting.

LXXXIV. Nature has given to moſt animals, and even to many inſects and vermes, a heart; ſhe has denied it to others, and indeed to the moſt ſimple animals, being thoſe which are irritable over their whole body, however large, as the holothuria hydra.

LXXXV. The veins which carry back the blood from the whole body to the heart, if we except thoſe of the lungs, are two. Anatomiſts call them the cava, but they either never form one ſingle trunk, or for a very ſhort ſpace. Of theſe large veins, the inferior is the largeſt, and in man aſcends in the right ſide directly above the diaphragm. Towards the right it is ſomewhat gibbous, that it may meet the ſuperior cava, and poſteriorly it forms the ſeptum, which intervenes between the right and left ſinuſes. But the left ſide of the vein unites with the right auricle, whoſe fibres are continuous with thoſe of the cava. The ſame is true of the ſuperior cava.

LXXXVI. A cavity is thus produced, whoſe right ſide is free, convex, and compoſed by the union of the two venæ cavæ, and which is filled with fleſhy fibres, variouſly interwoven between the two ſimple membranes. The ſame cavity, at its anterior and left part, is perpendicularly oblong, and almoſt oval; anteriorly it is dilated; and, laſtly, upwards, it has an acute blind termination, detached from the heart,

and

and reſting upon the aorta. This cavity every where between the external membrane of the heart and its own very thin internal membrane, has very copious fibres, fleſhy, detached, almoſt parallel, yet obliquely interſecting each other, which ariſing from the right ſide of the whole cavity, and from the left, are extended round its anterior ſemicylinder, in the manner of parallel arches. Very minute oblique fibres connect theſe muſcular arches. This anterior and ſtringy part is called the auricle, but the right and poſterior portion is called the ſinus, which is ſmooth along the ſeptum of the auricles, and between the anulus ovalis and mouth of the heart to the left of the vena cava. In the auricle are three conſiderable muſcles, the anterior, poſterior, and inferior.

LXXXVII. Towards the left of the ſeptum, which divides the two auricles, almoſt in the middle between the two venæ cavæ, there is a depreſſion, as if imprinted, deeper above, leſs deep below, in which the ſeptum is exceedingly thin. I ſhall call it the foſſa ovalis. A fleſhy column bounds it on each ſide, by the junction of which, is formed an arch, convex upwards, whoſe fleſhy fibres are ſtretched around in the form of arches, while their lower and thinner roots are turned backwards towards each other. This I call the anulus ovalis; others, the iſthmus.

LXXXVIII. Where the aſcending cava opens into the right auricle, from the left tumid column of the foramen ovale ariſes a membrane of a creſcent ſhape, naturally entire, but from its thinneſs ſometimes reticular in adults; which being extended round the lower edge of the auricle, always growing thinner as it returns incurvated to the right, circumſcribes almoſt half the circumference of the auricle, and ſeparates it from the vena cava, in the manner of a ſeptum. It is called the valve of Euſtachius.

ſtachius. The foramen ovale we ſhall deſcribe hereafter.

LXXXIX. Into this ſinus and auricle, which, however, compoſe but one porch of the heart, the blood of the two venæ cavæ is impelled by the muſcular power which reſides in each of theſe veins; for as far as they lie within the breaſt, they are endowed with ſtrong and irritable muſcular fibres, by whoſe contraction the blood is driven into the neighbouring auricle.

XC. In like manner the auricle, when irritated, contracts in every dimenſion. Firſt, by the conſtriction of the muſcular lacerti of the auricle, its anterior ſemicylinder is reduced to a plane, while, by contracting at the anterior extremity or beginning of the heart, and at the poſterior, or ſinus, they draw the middle of the arch backwards. Then the appendix of the auricle deſcends and contracts tranſverſely, while the lower part aſcends; and thus the auricle is ſhortened. Laſtly, the left ſide approaches evidently to the right, and the right ſomewhat to the left, and thus the auricle is rendered narrower. Into the mouth of the heart, now free, the blood is impelled like a wedge through the aperture of the valves, ſo that the flat ſides of the valves in the right ventricle are every where applied to the ſides of the heart. The blood is now hindered from returning again into the lower cava, on the contraction of the auricle, both by the reſiſtance of the ſucceeding blood from the abdomen, and by the Euſtachian valve; and from returning upwards it is prevented, both by the ſubſequent blood and its gravity. It is driven back, however, both ways, if there be any obſtacle in the lungs.

XCI. The heart itſelf, in ſome meaſure, reſembles half a cone. The ſection, paſſing through the axis of the cone, and dividing it, is almoſt triangular, but with an obtuſe nearly bifid point, and flattened

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to the form of the diaphragm, refts upon, and is fuftained by it. But the convex furface of the cone is fo inclined within the pericardium, under the great blood-veffels, that its thicker femicircular cavity lies in the fuperior and left fide, the obtufe margin of the moderns; while below, and anteriorly, it is extenuated into a kind of edge, or the acute margin. The point is turned a little forwards. This is the fituation in man; for, in brutes, the heart being almoft parallel to the larger axis of the thorax, its apex only touches the diaphragm.

xcii. The whole heart is hollow; and continuous with the right auricle and finus, as they are called, it has its properly anterior, though formerly called its right ventricle, broad, refembling the fourth part of a cone, not fo long as the left ventricle, but larger, and terminating in the fhorter tip of the bifurcated apex. The mouth of this ventricle, where it opens into the auricle, is elliptical, and terminated by a white margin, not fo much tendinous, as callous and glutinous, on which a ftratum of flefhy fibres refts, and externally fome fat.

xciii. From this margin is extended, within the heart, a membranous ring, formed by a reduplication of the internal membrane of the auricle, floating within the auricle and fo far entire. But this fame ring, in that part which hangs within the ventricle, is divided into three unequal trapezic portions, in fuch a manner, that you may, in fome meafure, give them the name of valves; and reckon three of them. They are, however, continued parts of one ring, only broader here. Thefe were, by the ancients, named triglochines.

xciv. The furface of thefe valves which lies next to the fides of the heart is ftrengthened by tendinous fibres, which, meeting together in their courfe, are inferted by fome very ftrong cords, lying in rows on each other, partly into the fides of the heart, and partly into papillary or cylindrical mufcles,

muſcles, ariſing towards the right from the left part of the right ventricle, bifid, trifid, or even branchy. The largeſt is that which anſwers to the biggeſt of the valves, which is both the uppermoſt and that which anſwers to the adjacent mouth of the pulmonary artery. The middle valve lies next the ſeptum of the heart. The leaſt of them is the loweſt, and moſt anterior in the acute margin.

XCV. The uſe of this valve is evident; for, on the contraction of the right auricle (XC.) the blood contained in the right porch of the heart being forced into the open extremity of the auricle, that is, the mouth of the heart, ſeparates, in the manner of a wedge, the pendulous portions of the ring, called valves, and preſſes them to the ſides of the heart. Thus the right ventricle of the heart is filled, while the uppermoſt valve (XCIV.) ſhuts the pulmonary artery, leſt the blood, with the weak impulſe of the auricle, ſhould enter that artery; but that being firſt received into the heart, by its ſtrong contraction it may be more powerfully expelled into the artery.

XCVI. By this blood, copious, warm and heavy, the ſenſible fleſh of the heart is irritated and excited to contraction: for that the heart, on being irritated, will contract itſelf in a moribund, or recently dead animal, is proved by the injection of water, and inflation of air, renewing the motions of a heart after having become quieſcent.

XCVII. The motion of the heart is performed by muſcular fibres; the origins of which, in general, are from rings formed of firm cellular ſubſtance, ſuch as I have deſcribed in XCII. and with which all the large blood-veſſels of the heart are ſurrounded. The fibres from thence deſcend gradually in an oblique courſe towards the left ſide, and to the apex, in many ſtrata, ſometimes a little decuſſating, of which the middle ones are more tranſverſe, the outermoſt and innermoſt more direct. In the flat ſide of

of the heart (XCI.) the fibres are few; and fo thin, that next to the fat, the cavity is found almoft uncovered. The ventricle, which is denominated the left, is furrounded by very firm fibres; which, in the feptum, flightly decuffating, are interwoven with thofe of the right fide. Many of thefe fibres, in their progrefs towards the apex, defcend into the cavities of the heart, and being interwoven, even repeatedly, in the manner of a net, intercept mefhes hid amongft the mufcular lacerti, and form the flefhy columns mentioned at XCIV. Others, at the apex, convoluted in a fpiral direction, terminate the bifid ventricles with a firm mafs. A very thin and fmooth membrane covers both the external and internal furface of thefe fibres; but the external membrane, efpecially about the coronary veffels, contains much fat. I have not been able to obferve with fufficient precifion, any thing further in the human heart; becaufe it is the peculiar property of the fibres of the heart to be joined by branchy appendices, fo that they cannot be feparated any where without laceration.

XCVIII. But eminent anatomifts, whofe ingenuity and candour I refpect, have publifhed the evolution and defcription of thofe fibres. They allege, that the external fibres of the heart defcend to the apex, common to both ventricles; that in their courfe, fome infert themfelves into the feptum, while others perforate the left ventricle near the point, and being reflected, return along the inner furface of that ventricle, to the bafis, in a contrary direction. But there are other middle fibres, betwixt the aforefaid inner and outermoft ones, which being varioufly inclined, and towards the bafis principally tranfverfe, form the feptum. Other anatomifts have given figures and defcriptions of many layers of fibres, of which the external and internal have contrary directions, and the intermediate are tranfverfe. As thefe do not differ very much from my own obfervations,

vations, I by no means undertake to deny them, although I have never ſeen this diſpoſition ſufficiently manifeſt, and am acquainted with great anatomiſts who have not been more ſucceſsful than myſelf.

XCIX. Theſe fibres of the heart, like other muſcles, are furniſhed with nerves of their own, numerous and of various origin. The firſt and uppermoſt, on the left ſide, come from the uppermoſt cervical ganglion of the intercoſtal nerve. With it are joined others from the pharyngeal plexus, formed of the ſoft nerves, proceeding from that ganglion, and from the gloſſo-pharyngeal nerve; others are added from the trunk of the intercoſtal nerve; others from the middle ganglion ſeated on the ſtraight muſcle about the paſſage of the thyroid artery, which has branches both from that uppermoſt nerve, and from the trunk of the intercoſtal and phrenic nerves; and others from the recurrent nerve of the eighth pair. The nerves of the heart, originating from theſe ſources, woven together into a plexus, partly before the aorta, on which thoſe, hereafter mentioned, are alſo added; and partly after forming ſeveral ſmall plexuſes between the trachea and the large arteries iſſuing from the heart, form one or more plexuſes, in which the nerves of the right and left ſide are united, though ſometimes they remain diſtinct. From this plexus, or plexuſes, ſome branches paſs between the aorta and pulmonary artery to the right artery of the heart; others croſs the pulmonary artery, and go between it and the auricle of the ſame ſide to the left coronary artery; others behind the pulmonary artery to the ſame coronary; and others, again, deſcend very deeply behind the right pulmonary artery to the left ſinus and flat ſurface of the heart. To the plexus, above deſcribed, other large nerves are added from the fifth and lower cervicals, and ſometimes from the phrenic nerve, and from the loweſt cervical ganglion of the intercoſtal, with which

which are united very large roots from the loweſt cervical nerves. Theſe, larger, very ſoft, and tranſverſe, are partly mixed with the former plexus, and partly go to the lungs. Laſtly, ſome ſmall branches, uncertain as to courſe and number, come from the recurrent and eighth pair of nerves, variouſly inoſculated with the intercoſtals, and blended with the eighth pair. Thoſe nerves, which ſome eminent anatomiſts have ſeen aſcending through the foramen of the vena cava, from the great abdominal plexus, to the heart, I have never been able to find; although it is eaſy to diſcover the diaphragmatics ariſing in that place, of which, though having ganglions peculiar to themſelves, thoſe anatomiſts make no mention.

c. That theſe nerves conduce powerfully to the motion of the heart, is the opinion of eminent anatomiſts, from a conſideration of the common nature of muſcles; and from the increaſe of motion in the heart, on irritating the eighth pair of nerves, or brain, or ſpinal marrow, and from the languor that enſues upon tying thoſe nerves, for the moſt part either immediately fatal, or certainly within a few days, although it is poſſible to tie only a few of them, for the intercoſtal, and ſtill more thoſe from the uppermoſt thoracic ganglion, cannot be tied.

ci. But that ſomething elſe is comprehended in the cauſe, appears from the motion of the heart remaining undiſturbed in the living animal, after exceſſive irritation of the nerves; from its continuing after the moſt extenſive wounds of the head, and even of the cerebellum and medulla ſpinalis, nay, even in the heart, when torn out of the breaſt, chiefly in thoſe animals in which the lungs, being pervious, make no reſiſtance to the powers of the heart; moreover, from the lively action of the heart in the fœtus before the brain is completed, and in animals wanting the head. And all our experiments agree, that the quieſcent heart, in moribund, and finally

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in dead animals, when irritated by warmth, vapour, cold, poiſon, and eſpecially by a current of air, watery liquors, wax, or blood, or by an electric ſpark, is immediately contracted, and all its fibres excited to quick and violent motion, ſometimes general throughout the whole heart, and ſometimes confined to one part of it.

CII. Thus, then, there reſides in the fibres of the heart an impatience of ſtimulus; ſo that in various places of the viſcus, even when almoſt dead, wrinkles, and motions, appear to be propagated through it, as if from radiating points: again, the heart, when torn out and cold, on being pricked, inflated, or irritated, contracts itſelf; and the fibres of a diſſected heart, corrugate themſelves orbicularly, when it is no longer ſupplied either with nerve or artery. This irritability exiſts in a greater degree, and remains longer in the heart than in any other part of the body; ſo that, by ſtimulating it, the motion of the heart may be renewed at a time when that of no other muſcle can. The heart of the fœtus is more irritable, as well as larger, in proportion, than in adults; and very tenacious of its mobility, even in the cold. This mobility is inherent in the heart, and is neither derived from the brain, nor the ſoul; ſince it remains in the dead animal, and in the heart when torn out of the breaſt; and cannot be accelerated or retarded by volition.

CIII. The heart, therefore, when ſtimulated by the venous blood thrown into it, contracts. This convulſive contraction is made with great celerity, and a manifeſt corrugation of the fibres; and the whole heart becomes ſhorter, thicker, and harder. The left ventricle is drawn ſomewhat towards the ſeptum of the heart, and the right one more ſo. The baſe alſo advances towards the apex; but the apex more evidently towards the baſis. This I have often obſerved with the greateſt certainty in

diſſecting

diffecting living animals; fo that thofe learned gentlemen muft have been fome how deceived, who have afferted, that the heart is elongated during its contraction. But the heart does not feem to turn pale in warm blooded animals. Even the feptum of the heart is rendered fhorter, and draws itfelf towards the bafis. By this action, the flefhy parts of the heart fwell inwardly, and comprefs the blood, as they do the finger when introduced within it. But that the heart is completely enough emptied, appears both from the event; from the evident palenefs in animals whofe heart is white, as frogs and chickens; and from the uneven internal furface, which has every where eminences and correfpondent hollows, and thick reticular columns interrupted by furrows. Befides, the apex of the heart, being turned a little forwards, like the radius of a circle, and being, moreover, driven forwards by the left venal finus, which is at that time, particularly filled, ftrikes againft that part of the pericardium next the thorax, about the fifth or fixth rib. In ftrong exfpiration, it is carried with confiderable force upwards and forwards. Both facts are proved by experiment.

CIV. The blood, preffed by the contracted heart, (CIII.) endeavours to efcape in all directions; but fince the contraction begun in the fides of the heart drives the blood towards the axis of the ventricle, that part of the blood which lay betwixt the venous ring (XCIII.) and fides of the heart, carries the ring before it, and extends its loofe extremities inwards. As this happens to the whole circumference of the ring, it becomes extended, throws back a part of that blood which had defcended into the cone of the open valve, into the right auricle; and, laftly, fhuts up the venous orifice more clofely as the heart contracts more ftrongly, and without doubt would force the tricufpid valves, as they are called, invertedly into the auricle, if the papillary mufcles (XCIV.) did not keep down their edges, and by

by their contraction, which is the ſame with that of the heart, retain them firmly in that poſition in which the chords connected with the valve are extended, without being injured.

CV. But the ſame effort of the blood opens to it another paſſage. Whilſt the right larger valve (XCIV.) approaches towards the axis of the heart, it leaves the mouth of the pulmonary artery, which it cloſed, and the blood opens it, preſſes the valves placed in the artery cloſe to its ſides, and ruſhes into the artery.

CVI. From the upper part of the poſterior, or, as it is called, the right ventricle, a paſſage leads into the artery, received as it were between productions of the fleſh of the heart, and ſtrongly connected to the heart by a cellular, callous ring, from whence the artery aſcends to the left and backwards, and paſſes behind the arch of the aorta. The ſtrength of this artery is moderate, being much weaker than the aorta. From the inner ſurface of the artery, where it is joined to the heart, the ſemilunar valves ariſe. Each of theſe is formed by a reduplication of the arterial membrane, extended from the part of the artery next the heart, upwards, in an obtuſe and ſufficiently flat arch. On the whole, they are parabolical with a looſe and moveable margin. The middle of the edge is generally divided, ſometimes in the fœtus itſelf, by a ſmall callous body, almoſt conical, but made up of inclined planes; ſo that the margin, which would otherwiſe have the ſhape of a creſcent, is now divided into two creſcents. Betwixt the two membranes of the valve, ariſing from the edge and firm root of the valve, appear ſome muſcular or tendinous fibres, partly tranſverſe, ſome of which even bind the valve to the contiguous ſide of the heart, leaving ſometimes ſpaces betwixt them in a reticular manner. Other fibres aſcend from the baſis of the valve; and adhere to

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the callous corpuſcle. Theſe draw back the valve, and open it.

CVII. Each of theſe valves with the ſide of the artery at this part ſomewhat enlarged, intercept a parabolical ſpace, which towards the heart is impervious; but open upwards, as we obſerved of the valves in the veins (XLIX.) When, therefore, the blood is impelled towards the axis by the contraction of the heart, it eſcapes in the direction of that axis; penetrates like a wedge, betwixt the valves, preſſes their looſe membranous edges againſt the ſides of the pulmonary artery, and flows out freely. This appears from the mechaniſm, from injection, from ligatures, and from the increaſed ſize of the cavities of the right ſide of the heart, when the lungs, being obſtructed, prevent them from being emptied.

CVIII. The blood received into the pulmonary artery, circulates through the lungs. That artery is firſt divided into two branches; of which the left is leſs and ſhorter, and enters immediately into the lungs of that ſide: but the right branch, larger and longer, paſſes tranſverſely behind the arch of the aorta to its correſponding lungs. From each of theſe, by ſucceſſive ſubdiviſions, very minute twigs are produced, of which, a part exhale a watery liquor into the cells of the lungs, and a part are continued into the veins. That the blood flows in this direction, is proved by the mechaniſm, by the application of a ligature, which, intercepting the blood between the heart and lungs, dilates the artery; by polypuſes obſtructing the mouth of the pulmonary artery, in which caſe the right cavities of the heart become monſtrouſly enlarged, and at length burſt, while the left remain empty; and by injection; for water, ſize and milk, are very eaſily thrown from the pulmonary artery into the vein, and into the left ſide of the heart. But in frogs, the anaſtomoſes themſelves of the arteries with the veins, are ſeen by means of the microſcope.

CIX.

cix. Nor can the blood, which has once entered the pulmonary artery, return into the heart; becauſe the valves (cvi.) are of ſuch dimenſions, that, when diſtended, they perfectly ſhut up the opening at the heart; and are ſo ſtrong, that they are able to reſiſt a much greater force than the contraction of the pulmonary artery. However, ſometimes, from the great preſſure of the contracted artery, they grow callous; or one of the membranes is lacerated, and oſſeous matter is poured in betwixt the duplicature of the valves. For, when the blood, by the contraction of the artery returns towards the heart, it ſtrikes againſt the open mouths of the valvular ſpaces, (cvii.) enters them, expands the valves, and forces them towards the central axis; when expanded, they ſhut up the paſſage, ſo that not even a ſlit remains, for that is prevented by the hard corpuſcles (cvi.)

cx. The pulmonary veins, of which we ſhall ſay more hereafter, are gathered into branches, and, at laſt, into four, ſeldom two, and ſtill more rarely into five trunks; to which cuſtom has affixed the ſingular name of pulmonary vein. Theſe trunks enter the cavity of the pericardium, from whence they receive an external covering; and are then inſerted into the corners of the ſquare, left, or poſterior, or as it is ſometimes called the pulmonary ſinus. The upper veins deſcend, the lower ones aſcend. That theſe veins bring their blood in that direction which leads to the ſinus, is proved by ligatures, which, by impeding the blood, cauſe a turgeſcence of the vein betwixt the ligature and lungs.

cxi. This left ſinus, almoſt cubical, firmly conſtructed of various faſciculi of fibres running between two membranes, has, on the anterior and right ſide, the ſeptum, common to it and the right ſinus, (lxxxvi.) but, at its anterior and left edge, it terminates in a conical appendix, notched and creſted with proceſſes, which, making two or three ſerpentine

tine turnings, is called the left auricle, and with its point directed forwards refts upon the left ventricle. As in the right auricle, fome of its fibres being bent into the form of an arch, contract the auricle; others, coming from the origin of the appendix, and inferted into its apex, deprefs it. This finus, with the left auricle, are fomewhat lefs than the right finus and auricle.

CXII. In this finus, the blood waits for the relaxation of the heart; at which time the nifus of the blood acting againft the venous valves, and ftronger than the action of the finus, remits. Then the left finus ftretches itfelf forward acrofs the heart, and at the fame time is contracted tranfverfely, and the appendix becomes evidently fhorter and narrower. Thus the left porch impels the blood into the left ventricle of the heart, in the fame manner as the right auricle impelled its blood into the right ventricle (XCV.) For, as in that, there is a valvular oval membranous ring, which has fimilar productions, called mitral valves, and which are ufually reckoned two in number. Thefe are longer and ftronger than thofe of the right fide. They have, in like manner, flefhy mufcles, one and one only to each, but much ftronger. And, more frequently than in the valves of the right fide, the valves, being fubjected to the powerful action of the heart, abound every where at the beginning of the tendinous chords with cartilaginous tumours.

CXIII. Therefore there comes into the left ventricle the blood, which the venæ cavæ had fent into the right auricle (LXXXIX.) this auricle had poured into the correfponding ventricle (XCV.) the ventricle had propelled into the pulmonary artery (CV.) and from it, being received into the pulmonary veins, was conveyed into the left finus (CX.) and driven by it into the left ventricle (CXII.) This conftitutes the lefs circulation, and was known to many of the ancients (LXII.) It is proved, by the

increaſed bulk of the left pulmonary veins, and of the veſſels of the right cavities of the heart, on the entrance into the left ventricle being obſtructed.

CXIV. The left, or poſterior, or upper ventricle, the firſt formed, and in many animals the only one, occupies that part of the half conical heart, which we called obtuſe (XCI.) It is narrower than the right ventricle, a little longer and rounder, and its cavity, on the whole, ſmaller. For, the capacity of this ventricle is about two ounces, while that of the right amounts even to three. Its texture internally is in like manner reticular, but more minute; and alſo at the mouth of the artery ſmooth. Its force is greater, as the muſcular fleſh, with which it is ſurrounded, is much, almoſt three times, ſtronger. The ſeptum of the heart belongs moſtly to the left, but ſome part of it alſo to the right ventricle: the whole of it is equally reticulated; but ſolid, and does not ſuffer any injected liquid to paſs from one ventricle to the other.

CXV. The left ventricle, from the ſame irritable nature, already ſpoken of, (CIII.) being ſtimulated by the blood thrown into it, contracts, and with great energy forces the blood contained in it towards the axis and baſis, while the cone of the heart is retracted nearer to the baſe. And ſince there is the ſame apparatus of valves, the blood diſtends the venous ring, and removes the right diviſion of the valve from the mouth of the aorta which it ſhut up, opens to itſelf that mouth, preſſes the ſemilunar valves, there placed, againſt the ſides of the aorta, and ruſhes into that artery with a violent impetus. This is proved by ocular demonſtration in living animals, and by the enlargement of the left ventricle on obſtructing the paſſage into the aorta.

CXVI. The valves of the aorta are not very different from thoſe in the pulmonary artery. Only as the aperture is here greater, ſo the valves themſelves are larger and ſtronger, and are ſeldomer

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without thofe callous globules. The fibres too of the valves, both tranfverfe and afcending, are fomewhat more confpicuous.

CXVII. After the contraction of the heart, follows its relaxation or diaftole, in which it becomes empty, lax, and foft, recovers its former length, the ventricles dilate from the feptum, and the bafis recedes from the apex. But as the blood diftending the auricles, lies immediately at the orifices of the ventricles, it rufhes through the valvular apertures, and feparates the oppofite fides of the heart, which is thus rendered both larger and longer. After the auricles have emptied themfelves of the blood they contained, they become in like manner relaxed, and their oppofite fides feparate from each other. Thefe ventricles are then filled with the blood, collected in the venæ cavæ and pulmonary veins, by the contraction of the veins; and, like the ventricles, are increafed in every dimenfion, and even the proceffes of the crefted margin are diftended and expanded. That there are in the heart dilating fibres, is contradicted by the connection of its fibres, which, being bound together by intermediate branches, cannot be feparately moved, and by the diffections of living animals which fhow that the whole heart is contracted at the fame time.

CXVIII. But it muft be obferved, that thefe motions of the right and left auricles, and of the right and left ventricles, are not performed in that fucceffion in which, for the fake of method, we have defcribed them; for both the auricles are contracted, while the ventricles are relaxed, and the contraction of the auricles precedes the contraction of the ventricles; as we are convinced, from manifeft experiments on dying and on cold blooded animals. But both auricles are filled in the firft inftant, and both of them are emptied in the fecond inftant; and both the ventricles are contracted in the third inftant, which however correfponds to the firft;

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and both ventricles, being evacuated, are relaxed in the fourth inſtant, which correſponds to the ſecond. Thoſe who have taught otherwiſe, have not taken ſufficient aſſiſtance from experiments on living animals. That the auricle, near death, makes frequent palpitations, before the ventricle of the heart performs one contraction, and that the motion of the right continues after the left has ceaſed, is certainly true. The auricle, with its ſinus, forms one cavity, and both are filled at one time, and both emptied in the ſame inſtant.

CXIX. But it may be aſked, why the heart, with inceſſant motion during ſo many years as there are in a lifetime, during ſo many days as there are in a year, and when, in each hour, in a healthy perſon, it contracts not much leſs than 5000 times, never reſts, but contraction perpetually ſucceeds repletion, and repletion contraction, in conſtant ſucceſſion; nor is the heart fatigued or pained by ſo exceſſive an action, that no other muſcle could endure it even for a few hours? To this queſtion, different profeſſors have given different anſwers, founded upon a compreſſure of the nerves betwixt the large arteries; upon an alternate repletion of the coronary arteries and heart, &c.

CXX. But to me the ſimplicity of nature ſeems very conſpicuous. When the auricle is relaxed, it is filled by the muſcular force of the contiguous veins, and ſo the heart in like manner contracts itſelf, when it is irritated by the blood conveyed through the auricle. Therefore, the heart, when it has received the blood, in conſequence of that irritability and ſtimulus by which its fibres are excited to action, contracts, empties itſelf of the blood, and, being freed from the ſtimulus, reſts and becomes relaxed. But being now relaxed, it is again filled by the contraction of the auricle, which the ſame ſtimulus of the venous blood excites, ſince the inceſſant action of the heart and arteries continually

ly ſupply blood to the auricle. That this is the fact, is proved from obſervation; which readily diſcovers the ſucceſſion of repletion and contraction in the vein, auricle, ventricle, and artery, in an exhauſted animal; but more evidently, in thoſe animals which have but one ventricle; as the tortoiſe, frog, ſnake, fiſhes; and in the chick in ovo, which, inſtead of a heart, has only a crooked canal. The ſame is alſo confirmed by the quieſcence of the heart, upon tying the veins; and by its motion, on removing the ligatures, if this obſervation be correct, but more certainly on the injection of air or fluids; and laſtly, by the perpetual contraction of the heart of a frog, upon a veſicle of air blown into it; which, it will force into the auricle, and receive, alternately, for many hours. The left ventricle firſt ceaſes its motion; then the auricle of that ſide; then the right ventricle; after that, the right auricle; and, laſt of all, the pulmonary veins, and venæ cavæ. The motion aſcribed to the venæ cavæ, proceeds from the auricle, repelling into both theſe veins the blood, which the heart, when dead, does not receive.

cxxi. Nor do I believe any thing more required, than a continual ſtimulus applied to a part irritable in the higheſt degree. For, even in the article of death, the very coldneſs of the limbs, which the warmth of life has left, conſtricts the veins, and drives the blood to the heart; at which time the lungs, being impermeable for want of reſpiration, tranſmit no blood to the cavities of the left ſide. On the other hand, the heart, thoroughly emptied, remains at reſt. It is, therefore, poſſible to transfer the prerogative of dying laſt from the venæ cavæ and right auricle, to the left auricle, and ventricle; if you contrive that the right cavities be emptied, and that the left be irritated by blood. But thoſe, who attribute the quieſcence of the heart to the compreſſion of its nerves, are refuted by the appearances

appearances in thoſe auricles, whoſe nerves are not compreſſed; as, for example, in fiſhes, and in the chick in ovo, where there is no ſuch compreſſion. If you deduce the quieſcence of heart from the coronary arteries, this is contrary to experience; ſince they are not covered by the valves of the aorta, and ſince, from the coronaries, when divided, the blood ſprings to the greateſt height during the ſyſtole of the heart.

cxxii. Nor, with the powers of the heart, do I conjoin the oſcillation of the minute veſſels, which is refuted by experiments: nor the influence of external heat; ſince animals are found to live and thrive in the coldeſt regions of the north: and though the contractile force of the artery, and the weight of the parts and of the atmoſphere, aſſiſt the motion of the blood during the diaſtole of the heart, the ſame powers reſiſt it during the ſyſtole; ſo that the blood is not moved more eaſily through the contractile arteries, than even through the rigid arteries of the ſmaller animals.

cxxiii. But the celerity and force with which the heart propels the blood, are variouſly computed. The more modern writers have calculated upon the following poſitions. In determining the celerity, they ſuppoſe two ounces of blood to iſſue out of the heart with ſuch a celerity, that that part of the pulſe, called its ſyſtole, is finiſhed within the third part of a whole pulſation, or within $\frac{1}{225}$ of a minute; and the area of the mouth of the aorta, they have eſtimated at 0.4187 parts of an inch: ſo, by dividing 3.318 inches, the ſpace filled by two ounces of blood, by the area of the aorta at its mouth, and by multiplying by 225, or number of pulſations, this quotient $7\frac{20809}{33180}$ inches, or length of cylinder of the aorta which is filled by two ounces of blood, they find 149 feet and two-tenths of an inch for the ſpace through which the blood would run in a minute, if it proceeded and paſſed through the

the cylindrical aorta with the ſame velocity with which it was expelled from the heart. But the weight of blood preſſing upon the heart, they have computed by the jet with which the blood ſprings from the aorta in a living animal, being ſeven feet five-tenths; and from the area of the ventricle, 15 inches; which produce 1350 cubical inches of blood, or 51 pounds five ounces, which preſs againſt the ventricle of the contracting heart. The heart, therefore, propels a weight of 51 pounds, with a velocity by which it may run through 149 feet in a minute; and this four thouſand eight hundred times in an hour.

cxxiv. Although into theſe calculations many things enter, which are neither eſtabliſhed, nor perhaps ever to be cleared up; although the mouth of the diſtended aorta is wider in a living animal; though the menſuration of the area of the ventricle is uncertain, and the jet of blood perhaps too low, if we conſider, that, in the living animal, the blood iſſues with violence from very minute arteries; laſtly, although we cannot determine what part of an entire pulſation the ſyſtole of the heart takes up, variations in which will, however, greatly alter the whole computation; yet, in the mean time, it will plainly appear, that the machine we call the heart is very powerful. This opinion is ſupported by experiment, which ſhews, that by anatomical injection, it is very difficult to fill all the red blood-veſſels, and impoſſible to fill all the ſmaller ones; while the heart not only gradually diſtends with blood all the large, ſmall and minute veſſels, but beſides, propels the blood with great rapidity. Even into the moſt minute arteries, the blood is driven by the heart with ſuch force, as to make its alternate motions perceptible. Likewiſe in the veins, and laſtly, in the ſmaller veſſels, both in cold blooded animals, and in the chick in ovo, there is no other force beſides that of the heart, by which

the blood is driven through theſe veſſels. And, from very ſmall arteries, I have ſeen the blood projected ſeveral feet, deſcribing a parabola, whoſe height was four, and its extent ſeven feet; and ſome aſſert, they have ſeen the blood thrown out of the aorta to the height of twelve feet.

CXXV. Moreover, in eſtimating the force of the heart in living animals, we muſt conſider the powerful obſtacles it overcomes: we muſt compute the enormous weight of the whole blood; for the entire maſs, weighing fifty pounds and upwards, when at reſt, is eaſily ſet in motion by the heart alone, as in the inſtances of fainting and reſuſcitation from drowning. We muſt, moreover, conſider the great decreaſe of velocity, ariſing from the greater capacity of the branches, which, even in the inteſtines, it ſeems we might compute at the 24th or 30th power of the root $\frac{3}{2}$. And yet fluids are carried with velocity through the ſmalleſt veſſels, of which we have examples in the Sanctorian perſpiration, which in ſubterraneous caverns I have ſeen riſing with great velocity, in the manner of ſmoke; and in the motion of the blood in fiſhes. Beſides, as friction in every machine conſumes the greateſt part of its powers, it will be readily conceived, that, in the human body, in which a liquid, much more viſcid than water, flows in canals ſo narrow, that they admit but one globule at a time, and not even that, without a change of figure, an exceſſive retardation muſt ariſe from friction, and that the power muſt be immenſe, which moves ſuch a maſs, in ſpite of ſuch obſtacles and diminutions of its force. But even aneuriſms and arteries are burſt by the force of the heart; and great weights along with the human body are elevated by the force of its ſyſtole.

CXXVI. The blood, when driven into the aorta, finds the mouths of the two coronary arteries near to the valves of the artery, but higher up and not

covered

covered by them. Into theſe, firſt of all, it ruſhes, and thus the heart ſupplies itſelf with blood. Theſe arteries are almoſt conſtantly two, and ariſe from the heart at an obtuſe angle with the trunk ; the right goes off between the aorta and pulmonary artery, and the upper and left one between the left auricle and the aorta. All the external branches are ſurrounded with much fat. Their cavity is not intercepted with valves any more than other arteries. Theſe arteries communicate, by ſmall branches, every where about the ſeptum and tip of the heart; but they do not make a complete ring round the heart. They terminate in two ways.

CXXVII. Their firſt termination is in the veins, of which the branches accompany the arteries, but the trunks neceſſarily ſeparate. The left artery is therefore accompanied by the great coronary vein, which is inſerted by a large opening, ſecured with a valve, or ſeveral little membranes, into the auricle to the left of the Euſtachian valve. It is diſtributed on the baſe of the left auricle, and accompanies the ſuperficial branches of the left artery.

CXXVIII. The ſecond vein (which you may make a part of the former, ſince they have both one common inſertion,) deſcends along upon the ſeptum of the heart on its flat ſurface; and may be properly called the median coronary. The third tranſverſely ſeeks the root of the right auricle, and terminates within, or at leaſt very near, the large opening of the coronary vein, (CXXVII.) or in an anterior vein. It ſupplies that part of the right ventricle which lies in the flat ſide of the heart; and often receives the vena innominata, immediately to be deſcribed.

CXXIX. There are ſtill ſome other anterior veins of the heart; but one, more conſiderable, which runs along that part of the right ventricle next to the margin, and winding in an oblique courſe, ſometimes between the membranes, is inſerted into the

moſt

moſt anterior part of the right auricle, and ſometimes into the trunk of the upper vena cava. This anterior vein ſends off along the root of the right ſinus, another which runs concealed through the very ſubſtance of the heart, and being again inſerted into the great coronary vein, completes the venous circle round the heart, like the arterial circle which ſome have deſcribed, but which to me is unknown.

cxxx. But there are a great many more veins, uncertain in their number and poſition, which, hid amongſt the origins of the large veſſels, belong to the deep ſeated and difficultly acceſſible parts of the baſis of the heart. Theſe open by numerous ſmall mouths into the right ſinus and auricle ; and, though more rarely, into the left ſinus. Thus I have ſeen a particular vein, which, from a latent ſinus in the fleſh of the right auricle, has aſcended towards the aorta and pulmonary artery, and inſerted itſelf on the other ſide into the greater coronary vein. I have ſeen another concealed betwixt the mouth of the coronary vein and the aorta, inſerted into the right ſinus ; and another along the remains of the foramen ovale, and ſeptum of the two ſinuſes, inſerting itſelf into the right ſinus ; and others again belonging to the venous valves ; beſides which, there are ſtill others too numerous to deſcribe. I have alſo ſeen a vein ariſing from the left ſinus, inſerted into the vena cava.

cxxxi. There are other ſmaller veins, whoſe little trunks are ſhort, and cannot eaſily be traced by diſſection. Theſe open by oblique ſhort mouths, through all thoſe innumerable pits of the right and left ventricles, and into the ſeptum of the heart, and into both auricles. Theſe are demonſtrated by injecting water, air, or mercury, eſpecially into the coronary arteries, after having tied all the correſponding veins ; or even into the veins themſelves, after having ſecured the inſertion of the largeſt trunks.

trunks. For, drops of coloured water, bubbles of air, ſpherules of mercury, exude through the whole extent of both ventricles; and this, without any violence that can be ſuppoſed to have burſt the veſſels. The paſſage from the arteries into the cavities of the left ſide, is, however, more difficult.

CXXXII. There are ſome who ſuppoſe that the coronary arteries are filled with blood, not by the contraction of the heart, but of the aorta. Their opinion is founded on the retrograde angle of their origin, on their mouths being covered by the valves, and on the paleneſs of the heart when contracted. But the two laſt of theſe are contrary to fact; and the firſt perhaps ſomewhat retards or leſſens, but certainly does not obſtruct the entrance of the blood; for the injections of air or mercury into the ſeminal and biliary veſſels every where, demonſtrate, that in a diſtended veſſel, even more retrograde angles do not prevent fluids from entering the branches. Moreover, in the coronary artery, the pulſe is ſynchronous with the other arteries in the animal body, and the blood, during the contraction of the heart, ſprings to a greater height (CXXI.)

CXXXIII. Concerning the reflux, there is leſs room for doubt: into the ventricles and auricles of the heart, right and left, but more into the latter, all the blood of the coronary veſſels is diſcharged, both by the large orifices, (CXXVII. CXXVIII. CXXIX.) and by the ſmall ones, (CXXX.) and by thoſe minute ones, (CXXXI.) which, when the large veins are tied, readily tranſmit injections. This circulation ſeems to be completed in a very ſhort ſpace of time, on account of the very great velocity the blood receives from the immediate action of the heart itſelf. I do not, however, think that it is effected during one pulſation; for the blood-veſſels of the heart neither loſe their colour, nor are completely evacuated. There is a very free

paſſage

paſſage from the arteries of the heart into the fat. What are the uſes of the minute veins? (cxxxi.) They return the blood of thoſe deeply ſeated arteries, which have no larger correſponding veins.

cxxxiv. The humours of the heart, which are thinner than blood, return by the valvular lymphatic veins, which accompany the coronary veſſels, and aſcend towards the thoracic duct and ſubclavian vein; they are very rarely to be ſeen, but I have obſerved them in brute animals.

CHAP. V.

NATURE OF THE BLOOD AND HUMOURS OF THE HUMAN BODY.

cxxxv. THAT liquid which is contained in the pulſating arteries and their correſponding veins, is called, by one common name, the blood. When ſuperficially viewed, it appears homogeneous, coagulable throughout, and redder in proportion as the animal is ſtronger and fuller fed; in a weak and famiſhed one it inclines to a yellow. Any admixture of white generally proceeds from chyle. But experiments of various kinds have demonſtrated the compound nature of this liquid.

cxxxvi. That fire is contained in the blood is proved from its heat, which, in man and ſimilar animals, is from 92 to 100 degrees, which is higher than the mean degree of atmoſpherical heat, but leſs than the greateſt. Beſides, from blood, when drawn, ſomething volatile or halituous, with a peculiar odour, intermediate between that of the ſweat and urine, eſcapes. When collected in proper veſſels, it appears aqueous, with a ſlight tincture of an alkaline nature.

CXXXVII. After the eſcape of this vapour, the blood of a healthy perſon, ſpontaneouſly congeals into a tremulous ſciſſile maſs; but with a degree of heat leſs than that of boiling water, (and indeed at 150°) it coagulates more completely even when perfectly healthy, though more eſpecially when taken from a febrile perſon. It ſometimes coagulates in the veins of a living perſon, and is found clotted in wounds of arteries. Even in a living perſon, and in one dying from the violence of fever, the blood has been coagulated into a tremulous jelly throughout all the veins. The principal part of this coagulum is the cruor, which has the red colour peculiar to itſelf, and imparts it to the other parts of the blood. This, condenſible by reſt, or a moderate degree of cold, and coagulable into a liver-like maſs by a heat of 150°, alcohol, or the mineral acids, is, however, ſoft, unleſs hardened by the attrition of life, or equivalent agitation. It is ponderous, and heavier than water by nearly an eleventh part; and, when freed from its water, it is wholly inflammable. In the maſs of blood, one half or upwards is cruor; and, in ſtrong robuſt people, the ſerum makes only a third part; in fevers, it is diminiſhed to a fourth or fifth part; and in diſeaſes from debility, it is increaſed.

CXXXVIII. From this coagulum there ſeparates, as it were ſweating out of its pores, but afterwards collecting in ſufficient quantity to allow the coagulum to ſink in it, another part of the blood which is white or ſomewhat yellowiſh, and alſo ſeemingly homogeneous, though it is not ſo. This part of the blood is, in general, one thirty-eighth part heavier than water, and almoſt a twelfth part lighter than the red globular maſs; coagulable by a heat of 150° or the addition of mineral acids or alcohol, or by agitation; it produces a firmer coagulum than the red cruor (CXXXVII.) and concretes into an inſoluble

ſoluble gluten, acquires a membranous appearance, and finally a horny hardneſs, with a friability like that of gum. Of it are formed the pleuritic cruſts, polypuſes, and artificial membranes. In the ſerum, beſides this coagulable albumen, there is contained ſimple water, which conſtitutes the principal part of the whole; and ſome mucous matter, capable of being drawn into finer threads than the red cruor; and not coagulable by fire or by acids as the albumen.

CXXXIX. Putrefaction alone, and the influence of a temperature of 96° diſſolves into a fetid liquor the whole blood, but eſpecially the ſerum; firſt the ſerum, and then the cruor more ſlowly; till, at length, the whole, both cruor and lymph, is changed into a volatile and feted exhalation; leaving very few feces behind. The blood, when ſomewhat diſſolved by putrefaction, both before it becomes fetid, and while fetid, evinces an alkaline nature, and effervesces with acids. Thence, in conſequence of putrefaction, it furniſhes leſs alkaline ſalt. When putrid, it cannot by any art be inſpiſſated; it is alſo very difficult to reſolve it after it has been coagulated by ſpirit of wine. By too ſevere exerciſe, heat of the atmoſphere, and malignant diſorders, the coheſion of the blood is diſſolved, and it aſſumes an alkaline nature almoſt as if from putrefaction.

CXL. Beſides theſe conſtituents of the blood, which are demonſtrated without ſubjecting it to any violence, it alſo contains a quantity of ſea-ſalt, which is diſcernible by the taſte, and ſometimes by the microſcope. Both nutrition and chemical analyſis demonſtrate, that the blood alſo contains earth, which is contained in the moſt fluid parts, and eſpecially united with the oil. By ſome very late experiments, it appears, that a conſiderable quantity of ferrugineous calx, eaſily reducible into a true metal by the addition of any inflammable body,

body, is contained in calcined cruor. Laftly, there is mixed with the blood condenfed air, and that in a very confiderable quantity ; the exiftence of which in the blood and ferum is proved by putrefaction, or by removing the preffure of the ambient air. The blood globules are not, on this account, air bubbles, for they are fpecifically heavier than the ferum.

CXLI. By the admixture of neutral falts, the colour of the blood becomes deeper and brighter, as by them it is neither diffolved nor thickened. It is fcarcely altered by weak acids. By ftrong ones it is coagulated. Fixed alkaline falts have almoft the fame effects as the neutrals. The volatile alkalies rather turn it brown, and coagulate it. Alcohol and diftilled oils coagulate it like ftrong acids. It does not effervefce with any falt.

CXLII. Chemiftry has opened various ways for inveftigating the nature of the blood. From blood recently drawn and perfectly frefh, by expofure to a gentle degree of heat, there is diftilled a large quantity of water, compofing five-fixths of the whole or more, almoft infipid, though impregnated with fome fetid oil, more ftrongly as the diftillation proceeds.

The refiduum, expofed to a ftronger fire, yields various alkaline liquors ; of which the firft, acrid, fetid, and of a reddifh colour, is ufually called the fpirit of blood ; it confifts of volatile falt and oil, diffolved in water, and amounts to one-twentieth part of the original mafs of blood. There is, moreover, an acid in fat, and in flefh even when putrid, and in blood.

Both before, and along with the oil, that next afcends in the diftillation, a dry volatile falt arifes, and adheres in branchy fleeces to the neck of the retort ; its quantity is fmall, about an eightieth part.

Another fluid, gradually thicker and heavier, at firft yellow, then black, and laftly of a pitchy tenacity,

nacity, acrid and inflammable, is the oil of human blood. Its quantity is ſmall, about the fiftieth part. There now remains, in the bottom of the retort, the ſpongy and inflammable cinder of the blood, which, being kindled, deflagrates, and leaves aſhes behind. From theſe, by lixiviation, is obtained a ſalt, conſiſting of ſea-ſalt, mixed with fixed alkali, and a ſmall quantity of inſipid earth. This fixed ſalt is ſcarcely the five hundredth part of the firſt maſs, and of this almoſt one-fourth is alkaline: when ſubjected to an intenſe degree of fire, it affords a little acid, which we ſuppoſe to ariſe partly from the ſea-ſalt, ſimilar to that demonſtrable in the ſpirit of blood; and partly from the vegetable nature of our aliments, not yet completely animalyzed. Hence it is found in herbivorous animals, as well as in man. But the earth, which is about the hundred and fiftieth part, contains ſome particles which are attracted by the loadſtone.

CXLIII. This analyſis ſhews that the blood contains various fluids, ſome more heavy and tenacious than others, ſome aqueous, others inflammable, and that moſt of them impart to the blood a putrid or alkaleſcent tendency. For, the blood, when healthy, and not injured by putrefaction, or too violent a degree of heat, is neither alkaline nor acid; but bland, and ſomewhat ſalt, although, in ſome diſeaſes, it is very acrid and almoſt putrid; as, for inſtance, in ſcurvey, where it corrodes its containing veſſels; and in dropſies, the waters of which are nearly alkaline. In inſects, there is found an alkaleſcent calx which efferveſces with acids.

CXLIV. By viewing with the microſcope freſh blood in a ſmall glaſs tube, or while it is yet moving in the veins of a warm blooded living animal, as a chicken, or of a cold one, as a frog, we perceive in it red globules; which doubtleſs, conſtitute the cruor mentioned in CXXXVII. Or are they

they rather lenticular particles of the ſame kind with thoſe obſerved by Leeuwenhoeck in fiſhes, and lately diſcovered in our own ſpecies; it is difficult to determine: nor, often as I have uſed the microſcope, have I ever miſſed thoſe ſhadows in the globules which indicate thickneſs and convexity.

cxlv. The colour of theſe globules is red; and ſo much the deeper, and more inclined to ſcarlet, the ſtronger the animal is: and in the ſame proportion, their number increaſes, when compared with the yellow ſerum. Their diameter is ſmall, being between $\frac{1}{2000}$ and $\frac{1}{3000}$ of an inch. They are ſaid to change their figure into an oblong egg like ſhape, which I have never been able to obſerve with ſufficient certainty. They are alſo ſaid to break down into other leſſer globules of a yellow colour, which I have neither obſerved myſelf, nor can eaſily admit.

cxlvi. Fibres are obtained in great quantity from the blood, and more ſparingly from the ſerum, by gradually waſhing it, when poured on a linen cloth, with much water; or by beating with rods, blood poured into water: they will amount to one eighty-fifth part of the whole. Theſe are formed of the gluten, and do not exiſt in the living animal; ſince they neither are perceived by the microſcope, which yet ſo eaſily renders viſible the red globules, although ſo much ſmaller, nor is their long thread like figure adapted for receiving motion.

cxlvii. From the preceding experiments compared together, ariſes that knowledge, which we at preſent have of the blood; namely, that the cruor is compoſed of globules. The inflammable nature of theſe globules is proved by the inflammation of dried cruor, and the preparation of pyrophorus from human blood: and, from theſe, moſt probably, proceeds the greater part of the

F pitchy

pitchy oil that is obtained from blood by the action of fire.

CXLVIII. The serum of the blood, subjected to the action of fire, yields almost the same principles with the red blood, viz. salt, oil, and earth, but more water and no iron. Similar principles, but with a less proportion of oil and salt, are obtained from the aqueous humours formed from the blood; as the saliva, and mucus.

CXLIX. The quantity of blood, contained in the whole body, cannot be very certainly computed. The weight of the fluids, however, is much greater than that of the solids; but many of them, as the gluten in various parts, and the fat, do not circulate. But if we may be allowed to form a judgment, from those profuse hemorrhages that have been sustained without destroying the life of the patient; from experiments made on living animals by extracting all their blood; and from the capacity of the arteries and veins; there will be at least fifty pounds of fluids which circulate, of which about twenty-eight will be true blood: the arteries contain about one-fifth, and the veins the other four parts.

CL. Nor are the proportions of the elements, which we have hitherto mentioned, constant: for, an active life, manhood, and fever, increase the cruor, redness, coagulability, cohesion of the parts, firmness of the coagulated serum, weight and alkaline principles. The serum, and the mucus it contains, are increased by the contrary causes; a less mature age, inactive life, and a watery and vegetable diet; by all which, the crassamentum of the blood is lessened, and its watery part increased. Old age, again, augments the cruor, and diminishes the gelatinous part.

CLI. On these principles, conjoined with a consideration of the solid structure, the diversity of temperaments depends. For plethora arises from an

an abundance of the red globules ; a phlegmatic temperature, from a redundancy of the watery part of the blood; a choleric diſpoſition in the fluids ſeems to proceed from a more acrid and alkaleſcent nature of the blood; as in thoſe who live on fleſh, and in anthropophagi, who appear to be more fierce than thoſe who live on vegetable food. In the ſolids, greater irritability, and hardneſs, with mobility, are attributed to a choleric habit ; a leſs irritability, with a more moderate denſity, to a ſanguine habit ; and leſs denſity, and leſs irritabilty, to a phlegmatic temperament. There is alſo a ſluggiſh temperament, in which remarkable ſtrength of body is joined with little irritability. In the melancholic, exceſſive irritability ſeems united with debility. But we muſt be cautious not to claſs too ſyſtematically the temperaments, which in nature are not four or eight, but infinite in their varieties.

CLII. The generation of heat ſeems to be the principal uſe of the red cruor, as its quantity is in proportion to the temperature of the blood. Being confined, by the largeneſs of the globules, within the firſt order of veſſels, it hinders them from collapſing; and, in receiving the common impulſe from the heart, on account of the greater denſity of its parts, it acquires a greater impetus, and ſets in motion the inferior orders of humours. Nor is it improbable, that the heart is more duly excited by the ponderous cruor. The globular figure of its parts, imparts to it fluidity connected with denſity; that quality, and perhaps the power of generating heat, are increaſed by the quantity of iron and of oil. Hence, when the red part of the blood is too much diminiſhed by bleedings, there follows a ſtagnation in the ſmaller veſſels; fatneſs and dropſy. From the ſame reaſoning, a due proportion of cruor ſeems neceſſary for the generation of new blood. For, in conſequence of hemorrhages, the blood degenerates

generates from its red and denſe nature, into a pale and ſerous ſtate.

CLIII. The coagulable ſerum is more eſpecially deſigned for the nutrition of the parts, as will be hereafter ſhewn, chap. xxx. The thinner fluids ſerve various purpoſes; as, the diſſolution of the aliments, the moiſtening the external ſurface, and ſurfaces of the internal cavities of the human body, to preſerve the flexibility of the ſolids, and conduce to the motion of the nerves, the ſight, &c. The ſaline particles ſeem proper for diſſolving the aliment, and ſtimulating the veſſels. The properties of the aërial part are not yet ſufficiently known. The heat produces its fluidity, and is not eaſily raiſed to ſuch a degree as to coagulate the fluids of the human body.

CLIV. Therefore, health can neither ſubſiſt without the thick blood, and a diminution of its quantity cauſes a ſtagnation in all the ſmaller veſſels, and univerſal paleneſs, coldneſs and debilty: nor can the functions of human life or health ſubſiſt without the fluids of the inferior orders, ſince the cruor, deprived of its watery part, congeals and obſtructs the paſſages of the veſſels, and produces too great a heat.

CLV. Is there any difference betwixt the arterial and venous blood? It ſeems probable, as the former has lately ſuffered the action of the lungs. But, in experiments, I ſcarcely find any difference obſervable, either in colour, denſity, or any other property; although, in other ſituations, I have ſeen it very apparently, for the bright red colour of the arterial blood ſeems to diſtinguiſh it from the duſky dark coloured blood in the veins; but this, in the plain example of the chick in ovo, ariſes only from the ſeries of globules being deeper in the thicker vein. Nor is there any eſtabliſhed difference in the blood of different arteries.

CLVI.

CLVI. From the ſame blood, driven into the aorta, are generated all the fluids of the human body. Theſe are reducible to certain claſſes. The means by which they are ſeparated, ought to be accounted for by the fabric of the glands. But we muſt firſt conſider what the blood ſuffers from its containing veſſels.

CHAP. VI.

OF THE COMMON FUNCTIONS OF ARTERIES.

CLVII. THE blood, driven from the left ventricle of the heart into the aorta, which, at its origin from the heart, bends firſt a little towards the right, and then to the left, and backwards, in a very acute arch, ſtrikes, in a maſs, firſt againſt the right ſide of the aorta, and is then reflected to the left ſide; whence, with a rotatory motion, as much as their fulneſs permits, it proceeds through the arteries, alternately ſtriking and rebounding from their ſides. The ſize of the aorta is a little increaſed, where it ariſes from the heart.

CLVIII. The arteries are, in a living perſon, always full of blood; ſince the blood ſpringing from an artery, is not interrupted by alternate ſtops during the relaxation of the heart, but flows on in a continued ſtream, and the microſcope ſhews the arteries, in living animals, to be full, both in their ſyſtole and diaſtole; nor can the circular fibres of the arteries contract themſelves completely, or entirely evacuate theſe tubes. Therefore, when into the full arteries there comes a new wave of blood, although it ſcarcely exceeds two ounces, and bears a ſmall proportion to the arterial ſyſtem throughout the body; it, however, overtakes the preceding wave, which being farther from the heart, moves ſlower; it conſequently drives the ſame forwards,

lengthens

lengthens the cylindrical artery, augments its diameter, preſſes the membranes cloſer to one another, urges the convex parts of its flexures outwards, and produces more ſerpentine turns, as injections demonſtrate. This dilatation of the artery, and change of its caliber, from a leſs to a greater circle, is called the pulſe; the diaſtole of which, is an expanſion of the artery beyond its natural diameter. It is peculiar to life, and reſults from the heart only, and is not natural to arteries left to themſelves. Hence, when the motion of the heart is intercepted, whether its impulſe be obſtructed by aneuriſm, or ligature, there is no pulſation; and hence, the ſudden ceſſation of the pulſe, in a living animal, on the heart being perforated. The artery is proportionally more dilated, the more ſlowly the preceding wave of blood eſcapes, and the more the velocity of the new wave exceeds that of the former.

CLIX. The contraction of the artery ſucceeds its dilatation. For the heart, having emptied itſelf, and removed the ſtimulus of the blood, becomes quieſcent. But the artery, at that inſtant, by the innate elaſticity reſiding in its circular fibres, being irritated by the ſame ſtimulus of blood thrown into it, contracts itſelf, and expels as much of the blood as it had received above its mean capacity: the whole of this quantity paſſes either into the ſmaller veſſels, or into the veins; for the ſemilunar valves of the aorta prevent its reflux into the heart, So ſoon as the artery has freed itſelf from this wave, being no longer ſtimulated, it remits its contractile action, and immediately yields to a new wave, propelled by the heart; and a new diaſtole enſues.

CLX. That the arteries contract, and by that means propel the blood, is proved by their contractile nature; by the evident remiſſion of the dilatation cauſed by the heart; by the ſpontaneous evacuation

cuation of an artery through its lateral branches, included between two ligatures; by the return of the blood to the heart, after its artery is tied, which blood, therefore, is not propelled by the heart; by the jet of blood from arteries being greater during the relaxation of the heart, as obferved by eminent anatomifts; by the vigorous projection of blood from the aorta when tied, below the ligature; by the evacuation of the arteries during the perfect quiefcence of the heart; by the veins being fuller than the arteries after death; by the confiderable jet of blood, to the extent of two feet, from the aorta in an animal after death; by the fmall caliber of the ill filled arteries in a famifhed animal; by the clofing of their orifices in wounds; and by the fphacelation of limbs, whofe arteries are offified, and the veins being in that cafe diftended with blood.

CLXI. The mean velocity of the blood may be computed, by diminifhing its velocity during the fyftole, as much as we increafe what remains of it during the diaftole, to be nearly fuch, as to move at the rate of two feet in a fecond. The conftant plenitude of the arteries, is the reafon why we cannot perceive any fucceffion in the pulfations of different arteries, and that in the human body they all feem to beat at one inftant, and at the fame time that the heart ftrikes againft the breaft. However, there certainly is a fucceffion, and the contractions of the aorta appear to follow in the fame order, as its repletion with the blood, expelled by the heart, fo that the part of the artery next to the heart contracts firft, and that thus the contractions proceed gradually to the ultimate arteries. This is apparent in the example of the inteftines, and may be feen in infects, whofe long and knotty heart manifeftly contracts fucceffively from the beginning to the end. But the mind of the obferver cannot dif-

tinguifh

tinguifh the minute portion of time, which amounts only to a few thirds.

CLXII. Where does the pulfe ceafe? In my opinion, in the ultimate and cylindrical arteries. We have noticed with what velocity the blood iffues from the heart. But that velocity continually decreafes. It is certain, that the aggregate capacity of the fmall arteries, always bears a larger proportion to the capacity of the aorta, as their divifion proceeds farther; and thus, notwithftanding the difference in the proportion between the trunks and their branches always decreafes, this proportion will be greateft, although it may be variable, between the aggregate capacity of the fmall arteries in their ultimate divifion, and the capacity of the aorta at its origin; and there will be a fimilar retardation of blood to that which occurs in aneurifms. Befides, the proportion of the coats of the arteries to their calibers always increafes as they are fmaller, until it is greateft where they tranfmit the globules fingly. This is proved from diffection; from inflation, by which every thing being reckoned, they are always more difficultly ruptured as they are fmaller; and by calculation, which eftimates the fize of the globules by the cylindrical membranes of the ultimate arteries. Add to this, the friction of a liquid paffing through minute and long tubes, bent and uniting at angles; which kind of friction diminifhes remarkably the velocity even of fluid water paffing through fimple and merely long tubes, and this always in proportion to their fmallnefs; and befides, the fmaller an artery is, the greater number of globules come in contact with its fides, and rub againft them. In confequence of the conical form of the arteries, the broader wave of blood coming from the trunk cannot pafs without refiftance through the fmaller aperture of the branch, and without endeavouring to diftend the branch: but alfo, the inflections and folds retard the

the blood; ſince ſome part of the impelling force is always ſpent in impinging on the convex part of the fold, and in the change of the figure of the inflected veſſel. Large angles likewiſe diminiſh the velocity, in proportion as they are more obtuſe, and recede from a ſtraight line. Moreover, the viſcidity of the blood itſelf muſt be taken into conſideration; ſince, by reſt alone, it immediately concretes into clots; and ſince it is from the circulatory motion only that this mutual attraction of coheſion in its parts is overcome, ſo as to prevent it from adhering to the ſides of the arteries, as it adheres in aneuriſms and wounds; and the globules from concreting together, as they uſually do after death. The oppoſition it meets with in the branches, leſſens the velocity of the blood likewiſe in the trunk: the oppoſite currents of blood in anaſtomoſes alſo deſtroy ſome part of its motion. Hence the immenſe retardation of the blood in the minute veſſels. We may eaſily perceive that it is very conſiderable, although it is difficult to eſtimate it. In the living animal, the blood flows in the trunk with the rapidity of a torrent: in the minute arteries, it for the moſt part begins to move ſlowly, and then to be coagulated. It is alſo well known to ſurgeons, that a ſmall branch of an artery near the heart or aorta, bleeds more dangerouſly than a much larger one that lies at a greater diſtance. The weight of the incumbent atmoſphere, of the muſcles and fleſhy parts lying above the arteries, and the contractile power of the veſſels, make a reſiſtance indeed to the heart, but do not leſſen the velocity of the blood, for they add as much during the diaſtole of the heart, as they take away from its powers during the ſyſtole.

clxiii. It is certain, however, from inciſions made in living animals, that the globules of blood, which move ſingly, do not loſe ſo much of their velocity as, by calculation, they ought to do. There

muſt,

muſt, therefore, exiſt ſome cauſes, which diminiſh the powers impeding their motion. And, indeed, it is certain, that, in the minute veſſels, the calibers of the branches do not bear ſo great a proportion to the trunk; their great ſmoothneſs alſo diminiſhes the friction. The facility, likewiſe, with which the blood returns through the veins, expedites its paſſage through the ultimate arteries which immediately communicate with theſe veins. No great effect can be expected from the weight of the blood, from the action of the nerves, or from their plexuſes, of which the firſt may both retard and accelerate occaſionally, and in living animals, the two laſt have no effect whatever. The power of derivation, whatever that is, and muſcular action, are capable of producing an increaſe of velocity.

CLXIV. The pulſe is therefore generated by the anterior wave of blood flowing more ſlowly, while the ſubſequent wave flows faſter; ſo that the former is an obſtacle to the latter (CLVIII.) But ſince the motion imparted to the blood by the heart weakens in its progreſs, and the contractile power of the arteries increaſes, therefore the exceſs of celerity of the poſterior wave, which comes from the heart, above that moved by the contraction of the minute veſſels, will be continually leſſening, till, arriving at a part where there is no exceſs, the pulſe will there ceaſe, from the anterior and poſterior waves both flowing with the ſame velocity, and therefore in one ſtream. This place will not be in the larger branches; for in them, the wave, laſt coming from the heart, moves quicker than what goes before; as is evident from the inflammatory pulſation, eſpecially of the ſmall arteries of the eye. But, in the ultimate arteries, the pulſe vaniſhes. This is evident from the equable motion of the blood in the minute arteries, often ſeen by the microſcope in frogs. Even in veſſels ſomewhat larger, the ſixth part of a line in diameter,

diameter, the pulſe ceaſes to be perceptible in the living animal. In the veins viſible by the microſcope, there is no pulſation or acceleration of the blood, whilſt the heart contracts, demonſtrable either by the microſcope or in any other way.

clxv. Even in the veins, the blood preſſes againſt their ſides, as appears from the furrows hollowed out in the bones, and the ſwelling of the veins on being tied. Why do not the veins beat? for we do not allow that to be a pulſe which is cauſed by reſpiration, or by the regurgitation of blood from the right auricle, or muſcular part of the vena cava. The reaſon ſeems to be, that the blood, when it immediately leaves the heart, is more retarded, and in the ultimate arteries, leſs. Hence the ſhort ſpace of time by which the velocity of the laſt wave exceeds the foregoing, is greateſt at the heart, and grows gradually leſs, till at laſt it totally vaniſhes. The following experiment is appoſite. Water forced in jets through a leathern tube, by means of a ſyringe, flows out of a bit of ſponge fixed at the end of the tube in one uniform and continued ſtream; and alſo the analogous experiment, where the ſame happens when water is thrown, in alternate jets, into the meſenteric arteries; for even then the water flows out of the veins in one continued ſtream.

clxvi. The pulſe is the meaſure of the powers exerted by the heart, becauſe it is the immediate and full effect of thoſe powers. Hence, all things conſidered as alike, the pulſe is ſlow in the ſtate of perfect health, where there is no ſtimulus, no reſiſtance acting as a ſtimulus, and the heart propels the blood freely and eaſily, except where there is ſome obſtacle, by which the blood is prevented from entering the aorta. From that cauſe, the pulſe in aſthmatic people is ſlow: and alſo from the debility or inſenſibility of the heart, the uſual ſtimulus is incapable of exciting it to con-

traction,

traction. A full pulſe is cauſed by the fullneſs of the artery, joined with a ſtrong force of the heart; a ſmall pulſe by the emptineſs of the artery, and a ſmaller wave of blood ſent from the heart. A hard pulſe denotes ſome obſtacle or ſtimulus, or increaſed action of the heart, with a greater thickneſs of blood, or a greater rigidity or obſtruction of the artery. A quick pulſe denotes ſome ſtimulus, obſtacle, or greater ſenſibility and irritability of the heart. The pulſe is beſt felt where the artery lies expoſed and ſupported by bone; but obſtructions ſometimes render the pulſe perceptible in the moſt oppoſite ſituations.

CLXVII. The pulſe is ſlower in animals as they are larger; becauſe the heart is proportionably leſs than in ſmaller animals, and, as well as the other parts of the body, is leſs irritable, and propels the blood to a greater diſtance; and becauſe there ſeems to be a greater increaſe of friction, than of power in the heart. Hence ſmall animals are more voracious; and large ones, as the whale and elephant, eat leſs. The pulſes of a healthy adult in the morning, are at leaſt 65 in a minute; in the evening they amount to 80; during the night they again become leſs frequent, and gradually return to the morning number. For muſcular motion, the action of the external and internal ſenſes, the warmth of the atmoſphere, and food and drink, urge the venous blood to the heart, which being thereby oftner ſtimulated, makes more frequent contractions. This is the cauſe of the evening paroxyſms obſervable in all fevers. Sleep retards the blood and every other motion.

CLXVIII. A frequent pulſe is different from a quick one; and it is poſſible for the pulſe to be at the ſame time quick and unfrequent. But it is difficult to obſerve a quick pulſe. The frequent pulſe is what is commonly called a quick one. It is frequent in children, and becomes leſs frequent in the progreſs

progreſs of life. In the ſalient point, the pulſes are 134; in new born infants, 120; and in old people, they decreaſe to 60. The febrile pulſe begins from 96. In fevers, or in an adult after muſcular action, 110 or 120 is a moderate frequency: but it is exceſſive at 130 or 140, with which number people ſeldom recover; nor have I ever obſerved it exceed that number. The pulſe beats ſlower in winter, and quicker in ſummer, often by 10 ſtrokes; and under the torrid zone, it increaſes to 120. The paſſions of the mind diſturb the pulſe in various ways. Whatever obſtructs the circulation, accelerates the pulſe; not from the laws of hydroſtatics, or on account of the canal being made narrower, or from the action of the ſoul; but ſimply becauſe the heart being with more difficulty freed from the ſtimulating blood, contracts itſelf more ſtrongly, and at ſhorter intervals. Irritation from acrid blood is frequently the cauſe of the febrile pulſe.

CLXIX. Through the minute veins the blood moves ſlowly, partly by the force of the heart, and partly by the contractility of the arteries. The firſt is proved by a renewal of the motion of the blood, in perſons drowned, which is effected ſolely by the excitation of the heart. But the contractile force of the arteries is proved by what we ſaid in CLX. After death, the blood is moved by its own gravity, and by the elaſtic air, generated during its putrefaction.

CLXX. The blood moves faſter in the larger veins. For wherever the impelling powers ſuffice, and the conveying tubes are rendered narrower, the motion muſt be accelerated; for venous trunks are ſmaller than the branches of which they are formed, in the ſame manner as arteries are leſs than the branches into which they divide. Therefore, if the motion of the venous blood loſt nothing in its way, the proportion of its celerity in the vena cava, to its celerity in the veins of the thirtieth diviſion,

would

would be exactly the thirtieth power of the proportion of the ſum of the calibers of all the ultimate veins, to the caliber of the vena cava. At the ſame time the friction is diminiſhed, and the contact of the blood with their ſides.

CLXXI. But ſince the blood moves very ſlowly in the ultimate arteries and incipient veins, and as the weight of the blood itſelf, in many places, impedes its return remarkably, and as, from the very thin coats of the veins, but little contractile power can be expected, nature has uſed various precautions, leſt, from the ſlowneſs of its motion, the venous blood ſhould ſtagnate or concrete. Therefore ſhe has reſtored to the veins, the halitus and fluid lymph, in larger quantity, as it ſeems, than what the arteries loſt, on account of the great exhalation from the lungs.

CLXXII. She has likewiſe placed the veins near the muſcles, which, by their ſwelling, compreſs the interpoſed veins; and ſince every preſſure of the veins, on account of their valves, determines the blood towards the heart (LXIII.) therefore all this force is entirely employed in accelerating the return of the blood to the heart. Hence that wonderful quickneſs of the pulſe (CLXVII.) heat, redneſs, and quick reſpiration after muſcular action.

CLXXIII. Moreover, thoſe muſcles, which ſtrongly compreſs on every ſide all the parts contained in any of the common cavities, powerfully promote the motion of the venous blood. In the abdomen, this is effected by the conjunct preſſure of the diaphragm and abdominal muſcles. Laſtly, the pulſations of the arteries, every where contiguous and parallel with the veins, promote the return of the venous blood; ſince, as we have before ſhewn, every impulſe acting on the veins can determine their blood to the heart only.

CLXXIV. To theſe is added the power, not yet ſufficiently known, of derivation, by which the blood

blood is brought from a place where it is more compreſſed, to one more lax, and where it meets with leſs reſiſtance. Laſtly, reſpiration is of great efficacy; in which the blood is alternately brought by the power of derivation from all parts of the body into the ſpongy lungs; and again, in exſpiration, is driven into the trunks of the veins in the head and abdomen. Hence the ſwelling of the veins, even of the brain, in the time of exſpiration. The circulation is not indeed aſſiſted by theſe cauſes, but the blood is agitated and preſſed forwards. The anaſtomoſes have the ſame effects as in the arteries; for they facilitate the paſſage of the blood from places where it is obſtructed, to thoſe which are pervious.

CLXXV. By theſe means, the blood in a healthy perſon, uſing ſufficient exerciſe of body, moves with a velocity, which is ſufficient to reſtore, in each pulſation, to the heart, by the vena cava, as much blood as the aorta carried away. But corporeal inaction and debility of the contracting fibres of the heart and muſcles, frequently render the motion of the venous blood more difficult. Hence the varices in pregnant women; and hemorrhoids, to which the abſence of valves in the vena porta contributes much. Hence the menſes themſelves. And when the veins return their blood too ſlowly to the heart, the ſubtle vapours being unable to return from the minute veſſels to the heart, ſtagnate and occaſion that frequency of œdema in weak people.

CLXXVI. The time in which an ounce of blood, ſent out from the left ventricle, returns to the right, and which is commonly reckoned the time in which the greater circulation is performed, is uncertain, and different in every different portion of the body. If, however, you inquire concerning the ounce of blood, when propelled in the quantity we have mentioned, with 4500 pulſations, about ſeven and a

half

half ounces will perform in an hour nearly twenty-three complete circulations and a half.

clxxvii. The effects of the action of the heart and arteries upon the blood, which follow from what has been mentioned, are various, and are estimated by comparing the blood of living with dead, of healthy with diseased, and of inactive with active animals. For the blood of a living animal is warm, is of a scarlet colour, seems homogeneous, although composed of mixed principles, is entirely globular, flows very readily through the most minute vessels, and exhales the volatile halitus, which we have already described particularly. In the dead animal, before it is tainted by putrefaction, it loses much of its red colour; it separates into heavier and lighter principles; exhales no vapour, and when drawn out from the veins, congeals either entirely or nearly so. But even in living animals, when weak, in which there is some pulse or respiration, though very small, the blood cools to a considerable degree. If, again, you compare the blood of a person inactive both in body and mind, with that of one addicted to violent exercise, you will observe in the latter, a greater heat, intense redness, greater compactness, specific gravity, and very great abundance of the volatile principles. All which appearances seem manifestly the effects of the action of the heart and arteries, since, with its increase, they increase, with its diminution, diminish, and with its cessation disappear.

clxxviii. That we may understand the manner in which these appearances are produced in the blood, we must consider what are the effects of the heart in expelling it, and of the arteries in alternately compressing it. And, indeed, the heart propels the blood with very great velocity (cxxiii.) The heart throws the blood into the crooked arteries, in a confused manner, so that the right globules, expelled into the mouth of the

aorta,

aorta, ſtrike againſt the left ſide of the artery; from whence being repelled, they incline towards the right ſide, and thus all the particles of the blood are agitated with a confuſed and whirling motion. It neceſſarily follows, that the blood, impelled into curved canals, muſt impinge on their ſides, dilate them and increaſe their convexity; and laſtly, in the ſmaller veſſels, capable of receiving but few or only one of the blood globules, in which the greateſt number or all the globules come into contact with the ſides of the artery, they ſo exactly rub againſt them, that they are even obliged to change their figure in order to paſs.

CLXXIX. But the arteries, by their elaſtic force, repel the blood from their ſides towards the axis of their cavities, and react upon it preſſing againſt them, and laſtly tranſmit the globules, ſingly, into arteries through the circular mouths of the ultimate ſeries.

CLXXX. In the arteries there is, therefore, a very great degree of friction; of the blood globules againſt the arteries; of the arteries contracting round the blood like an obſtacle; and of the particles of the blood amongſt each other by the confuſed and vorticle manner in which they are propelled. The effects of this friction are computed from the viſcid and inflammable nature of the blood, from the narrowneſs of the veſſels through which it runs, from the ſtrong impulſe of the heart, from the powerful reaction of the arteries, and from the weight of the incumbent parts raiſed by the force of the arterial blood. This friction generates fluidity, by perpetually removing the points of contact between its globules, reſiſting their force of attraction, mixing together the particles of different kinds, which become more fluid upon mixture, as in the inſtance of oil triturated with water. Then their rotation and mutual attrition diſpoſe the particles to aſſume a ſpherical figure; for by breaking off their protuberances,

tuberances, it renders thoſe that are ill formed or branchy more ſpherical. But even the fragments broken from the projecting ſurfaces of the ill formed globules, acquire a round ſhape from the ſame rotation, attrition, and circular caliber of the minute veſſels. Hence blood coagulates in the veſſels before death; and regains its loſt fluidity by reſtoring the motion of the heart, as we are taught by experiments made on living animals. Does the motion of the blood, and the denſity proceeding from it, produce the red colour, ſince it is nearly in proportion to the denſity, and increaſes or decreaſes from the ſame cauſes? It ſeems to depend on the calx of iron triturated with the oil.

CLXXXI. Does the motion of the blood alſo generate its heat, as in experiments with all kinds of fluids, and even air, but more eſpecially in a combuſtible animal fluid, denſer than water, compreſſed by contractile tubes, and rubbed in conſequence of rapid inflection and extenſion of the canals themſelves? Is this proved by the blood being warm in fiſhes which have a large heart, and cold in thoſe which have a ſmall one, as if the heat generated were in the proportion of the ſize of the heart to the body; by the great heat of birds, whoſe hearts are large; by the increaſe of heat by every motion, even friction; by the certain congelation of all the human fluids, at a degree of cold in which man freezes and retains his blood warm as long as he lives; and by the coldneſs of perſons whoſe pulſe is weak and obſcure? Nor does the heat proceed from any incipient putrefaction in the blood, ſince the fluids, when perfectly at reſt, do not generate that degree of heat nor is the evident phenomenon explicable from the action of ſuch an obſcure thing as the vital power; and though ſometimes the heat may be greater when the pulſe is ſlow, and leſs when it is more frequent, the difference may ariſe from the differ-

ent

ent nature of the blood, from the different denſities of the veſſels, or from the abundance or ſcantineſs of the perſpiration.

clxxxii. The ſame cauſe alſo checks putrefaction, by not ſuffering the inteſtine motion to be diminiſhed, by admixing antiſeptic particles, and by diſſipating others which have already begun to be corrupted.

clxxxiii. But in conſequence of the different natures of the particles themſelves, which conjunctly conſtitute the blood, the impetus of the heart produces different effects on the different particles of the blood. Namely, thoſe particles move more quickly, whoſe greater denſity makes them receive a greater impetus, and whoſe apt figure and leſs extended ſurface meets with leſs reſiſtance in the fluid in which they move. Thoſe alſo move more quickly, which, either from their weight, or from the direction in which they paſs out from the heart, move in the axis of the veſſel. Beſides, thoſe which have the greateſt projectile motion will ſtrike againſt the convexities of the flexures; while thoſe which, from their greater gravity or lentor, have leſs projectile motion, will move ſluggiſhly along the concavity of the veſſel. In this manner is the blood diſpoſed for the ſecretions.

clxxxiv. In the firſt place, the ſyſtole of the arteries produces compactneſs; ſince, by contracting round the blood as round an obſtacle, they compreſs it where viſcid and compreſſible, they expel the more liquid parts into the lateral mouths, increaſe the points of contact betwixt the globules, unite the larger, and compact the flat particles into denſer bodies. But the denſity of the blood is partly as the number of globules, and partly as the denſity of the ſubſtance of theſe globules.

clxxxv. Beſides, theſe very minute mouths, pervious to one globule, ſeem to be the meaſures

in which the ſanguineous particles, being approximated to a ſpherical figure by having their points rubbed off, now aſſume it and become perfect ſpheres. This is another ſource of denſity, ſince, of all figures, the ſphere is the moſt capacious.

CLXXXVI. The anaſtomoſes of the arteries remove every danger of obſtruction, for to any part of an artery where there may be an incipient obſtruction or coagulation of the blood, they admit an oppoſite current, by which the obſtacle is repelled in a contrary direction into a larger part of the trunk, and is comminuted between it and the direct current of blood. The irremoveable obſtruction or the loſs of any veſſel, is alſo ſupplied by the ſubſequent enlargement of ſome contiguous branch, as is proved by ſurgical facts, in which the principal artery has been cut or tied. The colliſion of theſe oppoſite torrents of blood takes ſomething from its velocity; and the reticular diſtribution augments the friction of the globules.

CLXXXVII. In like manner as the velocity, ſo the ſlow motion of the blood in the ultimate veſſels has its peculiar effects. In the larger arteries, the moſt heterogeneous particles are whirled about amongſt each other; in the ſmaller branches, the progreſſive motion of the blood being diminiſhed, the lighter particles ſeparate from the very ponderous and red globules, and are forced towards the circumference and branches, while the compact globules remain in the axis. The attractive powers of the particles of the blood are alſo increaſed; hence, the oily particles which are both ſluggiſh and large, attract each other, and ſeparate by open lateral mouths; and other thinner fluids are ſent off through lateral branches of a ſmaller orifice, till at length little more than the red blood alone paſſes into the incipient vein. Heterogeneous particles are alſo mixed in a ſingle vein, that the blood may be prepared for certain uſes, as in the vena portarum.

rum. But all theſe particulars which prepare the blood for the ſecretions, we ſhall conſider in the following chapter.

CHAP. VII.

SECRETION.

CLXXXVIII. THE fluids which, being depoſited from the blood into other veſſels, are ſaid to be ſecreted, ſeem reducible to four claſſes. The *firſt* conſiſts of viſcid fluids, coagulable by a heat of about 150 degrees, by alcohol, and by ſtrong acids; although generally, in the living animal, they eſcape in the form of vapour, and after death are compacted into a gelatinous ſubſtance. To this claſs belong the liquor and halitus of the ventricles of the brain, of the pericardium, pleura, peritoneum, tunica vaginalis, amnois, joints, renal capſules, and probably of the womb, with the juices of the ſtomach and inteſtines, and laſtly the lymph generally known.

CLXXXIX. The *ſecond* claſs conſiſts of fluids, of which ſome, in like manner, are exhaled, but more ſimple than the former (CLXXXVIII.) and more aqueous, are not coagulable by fire or by ſpirits of wine; and others are not exhaled, but, being depoſited in their reſpective excretory ducts, are excreted in their proper places by the common outlet of ſome gland. To the former of this claſs belong the perſpirable matter of Sanctorius, part of the tears, and the watery humour of the eye. To the latter of this claſs belong the remaining part of the tears, the ſaliva, pancreatic juice, and the urine. The ſweat ſeems to be a mixture of the perſpirable matter and the ſubcutaneous oil.

cxc. The *third* clafs differs from both the preceding, being heavier than water, fluggifh and vifcid, but of an aqueous nature, not congealable into a jelly, but hardening into dry crufts by exhaling their water. Thofe do not effervefce with any falt, but are contracted and made thicker by acids. By lixivial falts they are diffolved. By fire they are refolved into water, a little volatile falt, and a little oil. Of this kind are the whole mucus in the human body, extended over all the internal paffages for air, aliments, or urine, and the cavities of the genital parts ; and femen.

cxci. The *laft* clafs is that of the inflammable juices, which, when recent, are indeed thin and watery, but, by ftagnation and by evaporating their water, become thick, oily, inflammable, and often bitter liniments. To this clafs we refer the bile, earwax, tallow, the oily liniment of the fkin, the marrow in the bones, and all the fat throughout the human body ; and caftor, and the yolk of the egg. The milk itfelf, fo far as it contains butter, belongs to this clafs.

cxcii. Other humours are compounded of thefe which we have defcribed as fimple : as the mik, of butter and water ; and the liniment of the joints, of lymph and fat.

cxciii. Whoever confiders, that in the blood are found a coagulable ferum (cxxxvii.) an exhaling water (cxlii.) a fort of vifcid mucus (cxxxviii.) and laftly an oil (cxlii.) will begin to perceive the perfect poffibility of the foregoing claffes (clxxxviii. to cxci.) of humours being feparated from the blood, fince their principles exift in the fanguineous mafs. But in what manner it is brought about, that oil is feparated from the blood in one part, water in another, and mucus in a third, remains to be explained, and requires a defcription of the fecretory organs.

cxciv.

cxciv. The coagulable juices are ſeparated almoſt every where, from the arteries themſelves, into excretory canals, continuous with the arteries, without any intermediate organ. The proof of this we have from injections of glue, water, and thin oils, which very readily exude from the red arteries, and are poured out into all the cavities in which that coagulable vapour is naturally found, without meeting with any intermediate knots or retarding cells. Finally, the blood itſelf, being poured out into moſt of theſe cavities, without any permanent leſion, in conſequence of ſtagnation, retardation, or ſmall increaſe of impetus, ſhows plainly that the paſſage betwixt the red blood-veſſels and thoſe excretory ducts is neither long nor difficult, and that the yellow ſerum does not differ much from blood.

cxcv. Another liquid, coagulable by acid ſpirits and alcohol, is the albuminous humour of the joints, which being compoſed of fat, medullary oil, and watery exhalation, conſtitutes an exceedingly ſoft liniment, very fit for lubricating the cartilages, and leſſening friction. For ſecreting this, there are deſtined certain conglomerate glands of a peculiar ſtructure, which are ſo ſituated in the rough pits of the articulations of the bones, that they may be moderately compreſſed, but cannot be cruſhed.

cxcvi. The ſtructure of theſe glands is peculiar. The larger cluſters of glandular acini adhere, for the moſt part, to the bone by a broad baſis wrapped up in fat. Thence, being extenuated into a creſted edge, they pour out their liquor from an exceedingly thin border, by open ducts, which however I do not find very evident. Other ſmaller ones, placed every where in the capſules of the tendons, and between the diverging fibres of the ligamentary capſules of the joints, ſeem to be almoſt of the nature of ſimple glands, and are turgid with yellow mucous ſerum.

cxcvii.

CXCVII. The uncoagulable juices (CLXXXIX.) of the firſt ſort are ſecreted in the ſame manner with the coagulable ones (CLXXXVIII.) to wit, from exhaling arteries, which ariſe from the red arteries, without any intermediate follicle. In the veſſels, which exhale the cutaneous perſpiration, and in the lachrymal veſſels of the firſt ſort having a watery fluid; injections of water, or thin ſize exude from the arteries, ſo as to remove every doubt of this. Theſe arteries are alſo irritable, ſo that, from the contact of an acrid ſubſtance, they diſcharge more juice in a given time, than in a ſtate of health.

CXCVIII. But in the latter kind, the ſalival, the ſecretion is made by means of conglomerate glands, which the ancients firſt diſtinguiſhed by their cluſter like fabric, and eſteemed glands. Theſe are compoſed of acini or roundiſh lobules, conjoined together into a larger maſs, by looſe cellular ſubſtance, which is often covered externally by ſome denſe cellular membrane, as a common envelope, as in the parotid and maxillary glands. Through the intervals, betwixt the cluſters, run the arteries which are here pretty large, and the veins. But moſt of the conglomerate glands ſeparate their fluids from the blood, and diſcharge it in the following manner: Each acinus ſends out an excretory duct, which joins with others of the ſame kind, into a larger trunk, forming at laſt, in the manner of veins, one canal, which conveys the humour, ſeparated by the gland, to the part for which it is deſigned, as the cavity of the mouth, inteſtines, ſurface of the eyes, &c. There are, indeed, ſome inſtances in which either there are no excretory ducts, or they have not hitherto been diſcovered; as the thyroid gland, capſulæ renales, and thymus, unleſs theſe approach to the nature of conglobate glands.

CXCIX. The acini themſelves are ſurrounded and limited by ſome firm cellular ſubſtance; and are

alſo

alfo fubdivided into leffer acinuli, as is evident to the eye, and by the microfcope. How does this fubdivifion end? Is every fimple acinus hollow in its middle, receiving the humour tranfuding from the arteries in a follicle, and fending it out by an excretory duct? Is this ftructure rendered probable by eruptions, hydatids, and the kidneys filled with round fchirri? Are the larger vifcera, appointed for fecretion, conglomerated glands? Is this opinion made probable from the morbid round concretions formed in the liver, fpleen, kidneys, tefticles, and cortical fubftance of the brain; or from the bunch like appearance which thofe vifcera have in fmaller animals? In the cellular fubftance that furrounds every part of the human body, even the extreme vafcules, are there hollow fpaces and cells, into which a fecreted humour is poured?

CC. Nothing of this kind feems to be the cafe. For, indeed, the acini compofing the vifcera of animals, are not elementary, but compofite lobes, and large in proportion to the animals. The morbid concretions are almoft all of them feated in the cellular fubftance, and in the limbs themfelves, where there is not the leaft room to fufpect any thing of a glandular fabric; and are compofed of oil, earth, and vaporous particles, extravafated into fome of the cellular cavities, where, ftagnating and compreffing the adjacent follicles, they form to themfelves proper membranous tunics. Befides, the watery and fluid nature of the juice fecreted in thefe glands (CLXXXIX.) is an argument that, during its fecretion, it met with no retardation, no place in which it ftagnated. For the fluids which remain at reft in the warm cavities of the human body, which are full of abforbing veffels, are all infpiffated, and approach either towards a mucous or an oily nature. Moreover, anatomical injections would meet with more difficulty in paffing from the arteries into the excretory ducts; which would be impervious to thick injections,

injections, and thin ones would be exhaled into the cellular ſubſtance. Yet we ſee, that the ſuperlative art of great anatomiſts has conveyed thick injections, like wax, directly from the arteries of the ſalivary glands, liver, &c. into continuous excretory ducts; and this without filling up any intermediate cavities, which, according to the foregoing hypotheſis (cxcix.) ſhould happen.

cci. Therefore, the acini appear to be compoſed of arteries and veins, divided and ſubdivided, parted and connected by the intervention of a good deal of cellular ſubſtance, which, becoming gradually more compact, aſſumes a ſpheroidal figure. This is ſupported, by analogy in the lobes of the lungs, in the lobules of the thymus, in the ſtructure of inſects; but more eſpecially in the teſticle, of which the lobules are evidently formed of excretory ducts, connected together into faſciculi by a very ſoft membrane. The glands do not ſeem to pour their fluids into cellular ſubſtance, as by it the paſſage to the excretory ducts would be obſtructed or prevented. The induſtry of anatomiſts has lately diſcovered very ſmall, white, cylindric veſſels, the real elements of the viſcera; and it is to be hoped that this diſcovery will be confirmed by future obſervations.

ccii. Thin fluids, neither coagulable nor exhaling, but aqueous, are likewiſe generated in other parts, without the aſſiſtance of conglomerate acinous glands. Thus, the urine is depoſited from the red arteries into membranous tubes, manifeſtly continuous, in a manner which readily admits the paſſage of air, water, or mercury. The nervous fluid ſeems to be ſecreted in the brain, in a ſimilar, though leſs apparent manner.

cciii. The third claſs of fluids, the mucous, (cxc.) is almoſt every where ſecreted from ſinuſes or hollow glands. The ſtructure of true glands or follicles, in general, conſiſts of an ample cavity, every where circumſcribed by a membrane; but in ſuch a manner,

a manner, that the fleſh itſelf of the part, to which the gland adheres, ſometimes forms the one ſide, and completes the hemiſphere of the follicle. In other places, a continued membrane forms the whole of the round or oval receptacle of the gland. The cavity is in general round; but ſometimes it is oblong, and ſituated obliquely betwixt the adjacent parts; as, for example, in the urethra of the male, and in the follicles of the ſinus muliebris. They are irritable; and, when ſtimulated by acrid ſubſtances, accelerate their ſecretions.

cciv. Into theſe follicles minute arteries, either from the fleſh in which it is ſeated, or from the membrane which conſtitutes its convex ſide, open by extremities extended into the cavity of each crypta, into which they pour their reſpective juice; after being received into the follicle, it is detained from the narrowneſs of the excretory duct, and inſpiſſated, the more watery parts being abſorbed by the veins, which correſpond to the exhaling arteries. The truth of this we are taught from the ſtructure of the ſimple follicles obſervable in the tongue, in which both the importing pores, and the excretory ducts, are even viſible to the eye; and from the tubuli of the ſtomach of birds, in which the ſecreting villi manifeſtly protrude into the cavity; and laſtly, from injections, which force wax colourleſs into the ſimple glands.

ccv. The long mucous ſinuſes, and round glands, are both furniſhed with excretory ducts, which, for the moſt part, are ſufficiently large; although, in the round glands, they bear no great proportion to the cavity of the gland. Theſe orifices often open into the common large cavity, into which the mucus is poured, without any intermediate duct; as in the back of the tongue, and in the ſimple glands of the ſtomach and inteſtines. Theſe have been denominated cryptæ by Ruyſch. The ſinuſes have often a ſimilar ſtructure, and open,

open, without an intervening duct, as in the urethra of the male.

CCVI. In another kind of thefe glands, there are many fimple follicles contained in one common covering, which open with ample orifices into one common finus, without any true excretory duct, as in the tonfils. Thefe are called conglutinated glands.

CCVII. Other fimple glands have an excretory duct, by which they excrete their mucus; namely, a membranous, cylindric, narrow veffel, opening with its pofterior orifice into the cavity of the gland, and with its anterior orifice into the common cavity for which its mucus is defigned. Thefe excretory ducts are of confiderable length in the fubcutaneous and febaceous glands, and in thofe of the palate and windpipe. In fome parts, the pore and duct are more eafily demonftrable than the follicle, as in the noftrils, larynx, rectum, &c.

CCVIII. In other places, feveral of thefe ducts, arifing each from its refpective follicle, run together like the branches of a vein, fo as to form one confiderable excretory canal, common to a number of follicles. To this kind belong the compound glands of the inteftines, and the blind finus at the root of the tongue, of the clafs of glands; and of the finufes, fome compound finufes of the urethra, and the tubulous fibres of the ftomachs of fifhes and of birds. Glands of this fort may be faid to be compounded of fimple ones; but where they lie only contiguous, they may be called aggregate or congregated glands; as are thofe of the fauces, ftomach, inteftines, &c.

CCIX. The inflammable juices (CXCIX.) are feparated by organs differing in their fabric. The fat and marrow are depofited into cellular fubftance, without the intervention of glands, from the fmall mouths of the arteries. The fubcutaneous fat every where exudes through fmall ducts and pores, without

without any glandular follicles. But the earwax and cutaneous ſuet are ſecreted by glands of different kinds. Many of the ſebaceous glands are viſible, with a naked mouth in the ſkin, and without a duct of any length; as we ſee in the ears, areolæ of the nipples, in the female nymphæ, and the groove betwixt them and the labia, and in the prepuce of the penis and clitoris. Theſe differ but little from the cryptæ (ccv.) except in the matter which they ſecrete.

ccx. There are others of the ſebaceous glands, which have an excretory duct of ſome length; as almoſt all the cutaneous ones, which, being ſeated in the cellular ſubſtance, are neceſſarily provided with a duct to perforate the ſkin. This is moſt evident in the face, where the length of the duct is indicated by maggot like ſubſtance preſſed out; the bulk of which demonſtrates, that a follicle lies under the ſlender pore.

ccxi. There are ſtill other ſebaceous glands of the kind, mentioned ccviii. in which the ſmall ducts of many cryptæ meet together in one larger excretory duct. Thus, in the face, in ſeveral places, the large pores are in common to a number of cryptæ. Of this kind, alſo, are thoſe ſebaceous ducts in the eyelids; and the unguinous glands in the ſecretory organ of the muſk-goat, beaver, hyæna, civet-cat, and muſk-rat, which pour their ſebaceous matter into one common receptacle.

ccxii. The milk, which is compoſed of water and oil, and perhaps of abſorbed fat, and is a fluid of a peculiar nature, is ſecreted in a conglomerate gland, ſuch as we deſcribed at cxcviii. The bile is a matter of controverſy; but there are many arguments in favour of the vaſcular ſtructure, and of the bile being depoſited in the pori biliarii, from the vena portarum, without intermediate follicles; eſpecially the Ruyſchian art of injection, in which the wax paſſes directly from the porta into the biliary pores,

pores, without meeting with any intermediate knots retarding it. The milk and bile are both of them however much thinner, and more watery, than the fat, or the ſebaceous matter in follicles.

CCXIII. It remains for us to inquire, how it happens, that from one common maſs of the blood, the ſame variety of peculiar fluids are conſtantly ſeparated, each in its reſpective place, and that milk is never ſecreted in the kidneys, bile in the thymus, or mucus in the ſebaceous glands. This problem will be at laſt perfectly ſolved by one who ſhall be intimately acquainted with the internal ſtructure of the ſecreting organs. In the mean time, I ſhall notice what is hitherto known with ſufficient certainty.

CCXIV. In the firſt place, the blood itſelf, from which any liquid is to be ſecreted, aſſumes in various places, that peculiarity of character, that it contains more particles, of a like nature with thoſe which nature wiſhes to predominate in the fluid to be ſecreted. In the liver, the venous blood arrives with a ſlow motion, loaded with oil, and the ſemi-putrid vapours of the inteſtines. To the teſticles, the blood is brought ſlowly, through long, ſlender and inflected canals, ariſing at very ſmall angles, under the ſkin, in a cold ſituation. In the carotids, it is probable that the ſtronger, ſpirituous, and denſe parts of the blood aſcend; ſo that that is more watery, which deſcends into the abdomen and to the kidneys, and forms the ſaliva of the pancreas, and the gaſtric and inteſtinal juices.

CCXV. Beſides, the blood is prepared for ſecretion, by its retardation in the minute veſſels, in conſequence of which, the red and denſer parts alone occupy the axis of the canal; while the other lighter, more ſluggiſh, and leſs quickly moved particles, recede to the lateral branches, impinge on the ſecretory mouths ariſing from the ſides of the veſſels, and adhere to them by their viſcoſity.

CCXVI.

CCXVI. Thefe orifices, though poffibly of different diameters, are always too fmall to admit the blood in their natural ftate. As from an increafed action of the heart, many of them admit blood, we may conclude, with probability, that they arife continuous with the red arteries, and are not much fmaller than the red globules. Hence the fame fecretory orifices refufe thick injections of wax or fuet, and generally admit thinner liquors injected into the arteries. Therefore, this is the firft and moft fimple mechanifm of fecretion, viz. that the caliber of the excretory duct admits only thofe particles, of which the greateft diameter is lefs than the diameter of the duct. It is only in this way that the yellow arteries convey a pure liquor from the blood, and that the uriniferous ducts exclude the red blood and coagulable ferum. But this is not the fole caufe, fince fimilar fluids are generated by large, as well as by fmall animals.

CCXVII. Merely according to this law, the fecreted juices may be of many different kinds: for the very minute orifices will only admit fluids of extreme tenuity, as in the fmall veffels of the brain; while the larger will admit water and jelly; and the largeft of all, fat. Moreover, if a number of fecretory organs arife, in fucceffion from one fecerning artery, and be provided with large orifices, thofe which arife laft from the artery will admit only the thinneft fluids. If, on the contrary, thofe which arife firft in order from the fecreting artery, be fmall, the laft ones will receive only the groffer liquids. It may be objected, that though the veffels in the fœtus are vaftly lefs than in an adult, yet the humours are the fame. But thefe humours, which are called fat, bile, lymph, and urine, in the fœtus, are very different from the fat, bile, lymph, and urine of an adult.

CCXVIII. It is altogether in this way, that moft fecretions are made by veffels arifing immediately from

from ſanguiferous arteries (XLV.) Theſe ſeparate groſs juices; thick, coagulable, or watery; as the fat, urine, juice of the ſtomach and inteſtines, &c. But other ſecretions of thinner juices are performed by veſſels ariſing from the inferior orders of arteries, not ſanguiferous; to the orifices of which, not only no red blood, but no ſerum, fat, or other groſs fluids, can have admittance. Thus the more thin and pure humours muſt neceſſarily be ſeparated; as, for example, in the eye.

CCXIX. Perhaps the angle, which the ſecretory branch forms with its trunk, contributes ſomething to ſecretion. For it is eaſily demonſtrated, that at right and reflected angles, only the viſcid and ſluggiſh juices are expelled, in conſequence of the ſtronger force of the particles keeping the middle of the canal; and that the liquids which preſerve their velocity, are thoſe ſent off at acute angles. For men of credit have obſerved, that, in living animals, the velocity is greater in acute angles, and leſs in right angles. The very ſtructure of the body convinces us, that theſe angles have ſome effect on ſecretion, ſince in different parts we find the angles at which the branches proceed from the trunks different, and the reticulations different. For the ultimate veſſels are, in general, arbuſcular, the trunks ſending out branches on every ſide, but at different angles; thus, at ſmall angles in the large inteſtines, and large angles in the ſmall inteſtines. Thus in the ſpleen, the ſmaller red arteries ariſe ſo thick from their trunks, that they reſemble a ſprinkler; in the inteſtines, they reſemble pencil bruſhes; in the kidneys they are ſerpentine; in the liver radiated; in the teſticle, they are curled up like a lock of hair; and in the uvea they are anular. But it is no improbable conjecture, that the Creator never made this diverſity of fabric in vain. We have not as yet, however, any account of theſe reticulations that is ſufficiently accurate; nor

does

does a ſimilarity in the fluids ſecreted ſeem to be connected with a ſimilarity of ſtructure. The veins too have ſimilar reticulations, for the purpoſe of facilitating the motion of the blood, and not for diverſifying the nature of the ſecretions.

CCXX. The inflections of the ſmaller veſſels, as well arteries as excretories, greatly retard the motion of the blood; in which the greater part of the force received from the heart is evidently ſpent in the change of figure in the veſſel. The repeated inflections, therefore, of the ſecretory arteries collect the viſcid parts of the fluids, by giving them time to attract each other. A ſtraight courſe of the veſſels is favourable to celerity of motion, rendering the ſecretion copious and eaſy, but impure, as we ſee in the urine.

CCXXI. That the ultimate arteries, and in like manner the ſecretory orifices, have different degrees of denſity, is not improbable, ſince we actually find it ſo by experiments in the larger branches. But the denſer the capillary arteries are, the more will they admit only the ſtrong, and at the ſame time minute particles, and exclude thoſe that are lighter, moved with leſs velocity, and groſſer. Irritability produces almoſt the ſame effects; for if the ſecretory orifice be irritated, it will reject the groſs humours, and tranſmit the more fluid ones: inſtead of mucus in the urethra, it will ſeparate a thin yellow ſerum; and a ſimilar fluid, inſtead of the ſubcutaneous fat: the quantity of ſecreted liquor will alſo be increaſed; as, for example, in the tears.

CCXXII. Laſtly, the velocity is greatly increaſed, if the heart be near, if the artery be ſtraight, if it go off at a ſmall angle, or if the excretory duct ariſe near the extremity of a conſiderable arterial branch. The velocity is diminiſhed, if the ſecreting artery run a long way capillary, looſing the greater part of the motion of its blood, from friction, if it ariſe at a diſtance from the heart, and at a large angle.

 Finally,

Finally, from whatever cauſe the diverſity may proceed, an increaſe of velocity increaſes the quantity of fluid ſecreted, carries off the heavy liquids, and renders the ſecretions thicker and more impure, though fluid, as it prevents ſtagnation, by which they contract viſcidity: but ſlowneſs facilitates attraction and viſcidity, and renders the ſecreted juice more pure; as the ſimilar particles, when brought together, can better attract and join each other, under a ſlow motion, ſo as to retain the larger canal, while the thinner parts go off by the leſſer lateral branches. Hence, from the impetus of the heart alone being too much increaſed, all the ſecretions become confounded.

CCXXIII. Theſe conditions, nature is able variouſly to unite or ſeparate, and to impart to each organ, in greater or leſs degrees; and thus, to modify the ſecreted humours in various ways. Anatomy furniſhes examples, if you compare the ſecreting apparatus of the bile or ſemen, which are thick juices, with thoſe of the urine and tears, which are fluid ones.

CCXXIV. From all that has been advanced, we may perceive, that, ſince the blood contains particles of various kinds; ſome ſluggiſh and mucous; ſome coagulable, but fluid; ſome denſe and red; ſome watery and thin; and others fat and viſcid (CLXXXVIII. *et ſeq.*) among all theſe particles, thoſe which are the largeſt and moſt denſe, ſuch as the cruor, will continue in the axis of the veſſel, and in the trunk, ſo as to paſs on in a continued courſe into the ſanguiferous vein (XXXIX.)

CCXXV. Thoſe particles which are groſs and ſluggiſh, ſuch as the fat, muſt go off by the larger orifices ariſing laterally from the ſanguineous artery, by ſhort ducts; for in long ducts the oil would ſtagnate, from its ſluggiſhneſs. The phenomena of the ſecretion of fat (XIX.) agree with this deſcription. Such as are coagulable, but ſpecifically heavier

ier than thofe which are merely watery, and which continue fluid in the living animal, pafs from the red arteries, into others which are pellucid, but continuous to the red ones, and fmaller; whether thefe pellucid ones be continued on as trunks, fending off other fmaller branches, fuch as the arteries of the inferior orders (xli.) or whether they exhale their contents by a fhort extremity, like the veffels of clxx.

ccxxvi. Thin watery fluids may evidently pafs off by any veffels continuous with the fanguiferous, or inferior orders of veffels (xliv.) provided they be only fmall enough to exclude the groffer juices: whether thefe proceed from the fides of the larger veffels; or whether all the proper fluids being fent off through the larger canals, the fmaller canal be continued as the trunk, as in the eye. To the production of thefe fluids, the moft fimple fabric, even the direct continuation of the fecretory artery itfelf into the excretory duct, is fufficient, as feems probable in the urine. Therefore, in this cafe, the ftructure is direct and fimple, with few inflections, and with little diminution of velocity.

Such juices as, being watery, are light, but vifcid at the fame time, and confequently fluggifh and tardy, efcape eafily by fhort tubes appended to the fanguiferous arteries, and lefs than the adipofe veffels; and, therefore, it is evident, that thefe will be feparated from the blood more abundantly in fome parts of the body, where the velocity derived from the heart is lefs, the flexures of the artery more frequent, and the length of the capillaries greater.

ccxxvii. Has each part its particular ferments, form of pores, fpecific weight, and filters filled with their own peculiar humour, and refufing whatever is not analagous to it, which determine the nature of the fluids to be generated? Let thofe who adopt thefe ideas, confider the great varieties

there are in fluids, ſeparated in the ſame part of the body, according to the difference of age, courſe of life, &c. In the fœtus, the bile is ſweet; the ſemen thin, and without animalcules; the milk watery or abſent; the urine watery, mucous, and inſipid; the uterine mucus very white; the cutaneous veſſels full of a red fluid; the aqueous humour red; and the fat gelatinous. In the ſame organs, in an adult perſon, the bile ſecreted is acrid; the ſemen thick; the milk butyraceous; the urine, yellow, thin, and alkaleſcent; the menſtrual blood, and the aqueous humour, very limpid. But, even in the adult perſon, how different the aqueous urine, the concocted urine, and the heavy febrile urine, replete with ſalts and oils? The paſſions of the mind, which make no change in the body except upon the tenſion of the nerves, yet wonderfully change the ſecretions, and expel even the blood and bile through the veſſels of the ſkin. Add to this, the frequent diſturbance and alteration of the ſecretions from ſlight cauſes; ſo that, different augmentations of velocity ſhall cauſe different liquors to be ſecreted by the ſame organ: for blood has been known to paſs into almoſt all the paſſages of all the fluids; of the ſweat, tears, mucus of the noſtrils, and of the womb, milk, ſemen, urine, and fat. A true milk has been ſeen ſeparated by glands in the thigh. When the urine is not excreted, on account of ſome defect of the kidneys, ureters, or bladder, it has been exhaled into the ſkin, ventricles of the brain, or into the whole cellular fabric. The perſpirable matter of Sanctorius, though ſo fluid, by cold is ſent off by the urinary paſſages; and by fear, or by medicines, through the excretory villi of the inteſtines. That exhaling viſcid matter of the cellular ſubſtance is ſecreted and abſorbed, and by the ſame organs, alternately with the fat, ſo different from it (XVIII.) Salivation ſupplies the place of the exhaling fluid of Sanctorius, the exhaling

ing fluid ſupplies the internal. The bile, when abſorbed, evidently paſſes into the veſſels of the eyes. It appears, that there is not any thing in the particular fabric of any of the viſcera or glands, that can ſo fix or maintain the nature of the ſecreted fluid; that in perfectly entire organs, different fluids may not be ſeparated, by an increaſe or diminution of velocity, or alteration of the ſtricture of the nerves. The ſpecific gravities of the viſcera and ſtrainers do not correſpond, even according to their authors, to the ſpecific gravity of the humours which they ſecrete; nor are they at all known by experiments that can be depended on.

ccxxviii. It now remains for us to diſcover, how the pure ſecretions are formed in a healthy perſon. For all the fluids, when recently ſecreted, without excepting any, not even the oil, are mixed with a great deal of water; nor does it ſeem poſſible, that any of the thicker juices could be formed, without having a mixture of the thinner ones: how then do the ſemen, bile, oil, and mucus, get rid of their ſuperabundant water, and acquire their proper viſcidity and other qualities?

ccxxix. For this end, nature has framed glands and follicles, large and ſmall, for thoſe fluids from which the watery parts are to be ſeparated, in order to render the remaining part more ſtrong and viſcid. A ſlightly mucous water, differing at firſt very little from the perſpirable vapour or from tears, is depoſited in the follicles of the noſtrils, windpipe, and inteſtines. This is not continually diſcharging, becauſe the excretory orifice being leſs than the follicle (cxcvi.) and the excretory duct being ſometimes long and ſlender, at others repeatedly bent, and inflected or tranſmitted through hard cellular texture, or cloſed by ſome force equivalent to a ſphincter, the fluid is ſo retarded that it can ſcarcely eſcape without the aſſiſtance of extrinſic preſſure; unleſs perhaps the follicle being irritated

by

by its quantity or acrimony, preſs out the liquor incommoding it, by a kind of periſtalic motion. This appears from the morning diſcharges of mucus by blowing the noſe, coughing up from the lungs, and by ſneezing after the nocturnal ſtagnation. In the mean time, the patulent veins, extended into the cavity of the follicle, abſorb the more aqueous parts from the thin mucus, ſo that it becomes thicker as it is retained longer; but if, by the force of ſome ſtimulus, it be directly diſcharged after it is ſecreted, it comes out thin and watery. Examples of this we have in the urethra, in the noſtrils, and in the earwax; as alſo in the bile, which, at its firſt ſeparation in the liver, is watery, and has but little yellowneſs or bitterneſs. It is therefore detained in a bladder, and there digeſted by the vital heat; its thinner parts are abſorbed by the veins, or exude through the membranes themſelves; whence the remainder becomes more thick, bitter, and oily. The ſame mechaniſm takes place in the ſemen; which, being preſerved in the ſeminal veſicle, is there thickened, ſo as to be very viſcid after long chaſtity; while after repeated venery it is expelled very fluid. In ſome places nature has made this recepticle double or triple in the ſame organ, that the fluid might attain the utmoſt degree of viſcidity. In the ſeminal paſſages, the rete teſtis and termination of the epididymis, conſtitute a large canal, and a large veſicle; while the veſſels of the teſticle, vas deferens and proſtate duct, are narrow. Hence there are nowhere real glands, except for ſecreting a viſcid liquor. And if a viſcid liquor be ſeparated from arteries without a follicle, it always ſtagnates in ſome conſiderable follicle. The ſemen, bile, liquor of the joints, and fat, afford examples of this.

CCXXX. The fluids may be likewiſe changed in their receptacles by the affuſion of ſome new liquor.

quor. Thus the ſemen is thickened by the addition of the liquor of the proſtate; the chyle is attenuated by mixture with the ſaliva of the pancreas and the gaſtric and inteſtinal juices, and by the affuſion of the bile it becomes alkaleſcent; the albumen of the joints is tempered by the two kinds of fat (cxcv.)

ccxxxi. Laſtly, what is abſorbed, may have its uſes in the animal economy, after it is taken into the blood; thus the ſemen gives a ſurpriſing ſtrength to male animals. For the moſt part, likewiſe, in fluids which are detained, an acrimony of an alkaleſcent nature is generated, which alſo hath its uſes, as in the bile and ſemen.

ccxxxii. But the moſt important uſe of the follicles and receptacles is to preſerve their peculiar fluids, for thoſe times in which alone they are ſubſervient to life, and that a large quantity of them may be collected to correſpond with their uſes at certain periods. Thus the bile is reſerved for the time of digeſtion, the ſemen for due venery; and the mucus of the noſtrils is accumulated in the night to moderate the force of the air paſſing through them in the day.

ccxxxiii. Therefore, as nature has framed machines which retard the fluids in large or ſmall follicles, ſo ſhe has made others to expel them at proper times. To ſome glands ſhe has given particular muſcles; as in the teſticles of brutes, the urinary bladder, and the gall bladder, and in the inteſtines, and ſtomach; or ſhe has ſubjoined contiguous muſcles to promote the diſcharge, as the biventer, maſſeter, muſcles of the abdomen and diaphragm; or elſe ſhe has given them a kind of nervous irritability, which, being excited to action by an indeſcribable ſtimulus, opens the ſhut paſſages to the milk, ſemen, tears, &c. or from the contact of any thing acrid, as already mentioned, accelerates the diſcharge of the fluid; as hap-

pens

pens to the bile, liquor of the ſtomach and inteſtines, and to the ſebaceous matter.

CHAP. VIII.

RESPIRATION.

CCXXXIV. THE bags of the pleura (LXXVII. LXXVIII.) are filled by the lungs; by which we underſtand two viſcera, one right and another left, in figure correſponding with the bags themſelves which they fill, having a broad baſis below, and being terminated above at the firſt rib by an obtuſe cone. Anteriorly their ſurface is flat, laterally convex, and poſteriorly it is rounded; internally it is concave, eſpecially that of the left lungs, for the purpoſe of containing the heart. The right lung is the largeſt, and is moſt frequently divided into three lobes; which is ſeldom the caſe with the left. They are freely ſuſpended by the great blood-veſſels; unleſs you call that a ligament which is formed at the baſis of the diaphragm by the external membrane of the pleura going off to the lungs. Between the lungs and pleura is found a watery vapour, of a coagulable nature, like that of the pericardium (LXXXII.) which tranſudes from the ſurface of the lungs and of the pleura, continually in the fœtus, and not unfrequently in the adult. In dropſy, this vapour is increaſed, or thickens to a kind of ſebaceous matter; or, laſtly, it concretes into fibres, forming adheſions of the lungs.

CCXXXV. The external membrane of the lungs is ſimple, and thinner than the pleura, although continuous with it. It ſpreads, from the adheſion of the great blood-veſſels of the heart, over the lungs in every direction, and, when entire, may be eaſily inflated, even after being ſeparated from the

the lungs. The ſame membrane paſſes over the intervals between the lobules, like a bridge. It is joined to the lungs by cellular texture.

CCXXXVI. The lungs are made up of lobes ſeparated by intermediate intervals, in which there is looſe cellular ſubſtance. Their firſt diviſion is into two large lobes, and one middle one of a ſmaller ſize; which, however, cohere together: they are afterwards repeatedly ſubdivided into ſucceſſively ſmaller lobes, always ſurrounded by cellular membrane, till at laſt the lobules are reſolved into very ſmall membranous cells, which, in adults, are filled with air, are of various figures, and communicate on all ſides with each other. The elementary parts of the lungs, therefore, are not oval bags, ſurrounded by muſcular texture, with a ſingle orifice which receive the air from the windpipe, but they admit the air exhaling from the ultimate branches of the trachea, ſo that being effuſed into irregular ſpaces, it paſſes and repaſſes freely from any one portion of the lungs into all the others. This is demonſtrated by inflation, for air blown into any, even the moſt minute lobule, through its branch of the trachea, paſſes into all the reſt. In man and in the ſmaller animals, the cellular fabric of the intervals is neither ſhut up from the veſicles of the lungs, nor are the lobes ſurrounded by any peculiar membrane; in the largeſt animals, there is no communication between the air veſicles and the cellular ſpaces which ſurround the lobules.

CCXXXVII. The air paſſes into theſe veſicles through the windpipe. The windpipe ariſes from the larynx (hereafter to be deſcribed,) and receives the air through it alone. Its firſt part ſingle and ſimple, partly fleſhy and partly cartilaginous, the œſophagus lying below it and to its left, is ſupported on the broad and flat vertebræ of the neck; in other words, within the cellular ſubſtance that ſurrounds

ſurrounds the windpipe, there is ſituated a canal, compoſed of alternate cartilaginous and muſcular rings. The cartilaginous rings, thin and elaſtic, anteriorly ſomewhat flat and thick, are joined together by their poſterior extremities, which are thinner; and the circle is completed by ſtrong tranſverſe muſcular fibres, adhering to both the looſe extremities of the cartilage. The lower circles are leſs; the uppermoſt is often augmented by an appendix, that next to the diviſion is perpendicular.

CCXXXVIII. The fleſhy rings, ſituated alternately with the cartilaginous ones, are compoſed of red muſcular fibres. Some of theſe are tranſverſe, connecting the detached ends of the annular cartilages; others deſcend from each upper to the next lower ring. But other muſcular fibres again, deſcend from the cricoid cartilage, and having reached below the diviſion of the bronchia, vaniſh upon the lungs. The tranſverſe fibres contract the windpipe; the longitudinal ones ſhorten it. Within the lungs, between the imperfect rings, there is a ſort of muſcular fabric, but leſs uniformly diſpoſed.

CCXXXIX. In the cellular coat which ſurrounds the muſcular one, but eſpecially behind, in the interval between the cartilages (CCXXXVI.) are placed numberleſs ſimple glands, which, by very ſmall ducts, like pores, opening into the cavity of the windpipe, depoſite within that cavity a watery and pellucid mucus, not coagulable into films, and very bland, which is of the greateſt uſe in defending the exceedingly ſenſible membrane from the impurities of the air, which is loaded with particles, irritating by their mechanical figure or chemical acrimony. Numerous conglobate glands are ſituated around the trachea and its bronchia, but theſe are of the lymphatic kind, although their black fluid frequently penetrates into the trachea. Laſtly,

ly, the internal tube of the windpipe is lined by a membrane, covered by epidermis, continuous with the ſkin and membranes of the mouth, ſmooth, ſoft, and very irritable. It is connected with the muſcular coat by cellular ſubſtance.

CCXL. The veſſels of this entire part of the windpipe, in the neck, come from the lower thyroids ; in the thorax, from other ſmall branches of the ſubclavian trunks, or the mammaries, or the bronchials properly ſo called. Its nerves, ariſing from the recurrent and intercoſtals, are numerous.

CCXLI. In the upper part of the thorax, the windpipe is received between the laminæ of the poſterior mediaſtinum ; and at the third vertebra, or a little above, is divided into two branches ſimilar to the trunk, formed in like manner of imperfect cartilages, and furniſhed with ſimilar glands ; each of theſe enters the lung to which it correſponds, and the right is ſomething ſhorter and larger than the left. Having entered the lungs, the cartilaginous rings gradually degenerate into fragments, become more difform, gnomonic, angular, triangular, and intermixed with a larger portion of membrane, till at length, by the diminution of the cartilages, the ultimate branches of the bronchia become membranous.

CCXLII. Its ultimate branches are inviſible, and exhale air into the cellular ſpaces of the lungs in adults, and from the ſame ſpaces receive the arterial expired vapour.

CCXLIII. The veſſels of the bronchia, are the bronchial veins and arteries. The latter are generally two ; one coming from the upper intercoſtal of the aorta, which is diſtributed either to the right only, or to both the lungs ; the other, from the trunk of the aorta, goes to the left lung. Sometimes there are more ; as when there are three, by the addition of a ſecond from the aorta. At other times,

times, there is only one artery common to both lungs. The thoracic part of the bronchia, ſituated without the lungs, has its proper veſſels from the aorta, or from the ſubclavian, or the mammary, or the intercoſtal. The bronchial veins are very commonly two; the right from the vena azygos, the left from a peculiar branch of the ſubclavian vein, the left ſuperior intercoſtal. Theſe blood-veſſels accompany the branches of the trachea; and deſcend into their membranes, the arteries inoſculate with the pulmonary arteries, and the veins with the veins, forming a vaſcular web in the internal cellular ſubſtance. There are ſome inſtances where the pulmonary vein itſelf has given ſmall branches to the lungs, to the windpipe, and to the ſurface of the lungs.

CCXLIV. But there are other larger veſſels belonging to the lungs, the pulmonary artery (CVI. CVIII.) and the vein (CX.) The great artery, in the fœtus larger than the aorta, and in the adult but little leſs, has two branches; the right larger but ſhorter, the left narrower and longer. In the fœtus, the trunk itſelf is continued into the deſcending aorta, and is known by the name of ductus arterioſus. In the adult, that trunk degenerates into a ſolid ligament. The four pulmonary veins accompany the branches of the artery and of the trachea, through the lungs, ſurrounded by a good deal of cellular ſubſtance; which ſubſtance, being increaſed, at laſt compoſes the lungs themſelves. Within this cellular fabric, the air-veſſels and blood-veſſels are ſubdivided, and in the ultimate cellular ſpaces, the ultimate veins and arteries ſpread, reticularly interwoven; and here the ſmall arteries exhale a plentiful vapour into the aërial cells of the lungs, and the veins abſorb a watery vapour from them. Hence coloured water, the whey of milk, or thin wax, being injected into the pulmonary artery, flow with froth into the windpipe; or, on the contrary, penetrate from the

the bronchia into the pulmonary artery. In like manner, injections paſs from the pulmonary vein into the bronchia; or from thence, into the veins. Laſtly, they readily paſs from the arteries into the pulmonary veins; or return from the veins into the arteries.

CCXLV. The lymphatic veſſels, as in other parts, form a network upon the ſurface of the lungs, from whence branches run to the cavity of the poſterior mediaſtinum, to the glands ſeated on the œſophagus, and to the thoracic duct. The nerves are ſmall, eſpecially the anterior, the poſterior ones being ſomewhat larger: they come from a nerve of the eighth pair; but they receive ſome addition, accompanying the large blood-veſſels, from the recurrent, and likewiſe from the cardiac plexus. Hence the lungs have but little ſenſation; but that of the little nerves, divided upon the ſubſtance of the bronchia, is very acute. Nor are the lungs of an irritable nature.

CCXLVI. The quantity of blood which enters into the lungs is exceedingly great, equal to (or even perhaps greater than) that which is ſent in the ſame time throughout the reſt of the body; which, therefore, indicates this viſcus to be ſubſervient to ſome very important purpoſe. That this uſe depends manifeſtly upon the air, appears from the univerſal conſent of nature, in which we ſcarcely find an animal which does not reſpire; alſo from the ſtructure of the lungs in the fœtus, in which being uſeleſs, on account of the abſence of air, they receive only a very ſmall portion of that blood, which the pulmonary artery conveys from the heart. We come, therefore, to ſpeak of reſpiration, or the inhalation and expulſion of air by the lungs.

CCXLVII. Air, phyſically conſidered, is an element, fluid, inviſible, elaſtic, with an indeſtructible ſpring, and ſoniferous. But the air, which we commonly receive into the lungs, is impure, filled with a great quantity of watery and other vapours, alſo with

with ſalts, and the univerſal acid, with the ſeeds of plants and animals, and other foreign particles; and is ponderous; weighing, however, 850 times leſs than water, a cubic foot of air being between 610 and 694 grains. This air, which ſurrounds the earth on all ſides, being compreſſed by its incumbent columns, perpendicularly and laterally, enters with great force wherever it meets with leſs reſiſtance, as appears from experiments made in vacuo, and from the phenomena of the air-pump; ſo that its preſſure on the human body is not leſs than 30,000 pounds. It is repelled chiefly by the pores of membranes, though theſe are permeable by water: it likewiſe penetrates oil or mucus with difficulty.

CCXLVIII. The ambient air is excluded from all parts of the human body, by denſe ſkin, which, even when dry, is impervious to the air; by the fat lying under it; by the narrowneſs of the abſorbent veſſels, and by the equability of the reſiſtance. We muſt inveſtigate why the air enters the lungs, which in an adult are always filled with air, and therefore reſiſt the preſſure of the whole atmoſphere with an equivalent force. That the lungs always contain air, is evident; becauſe, however you compreſs them, they are ſtill lighter than water; and even after they have been inflated but a few times, they always ſwim; whereas, in the fœtus, before air has been admitted into them, they ſink to the bottom.

CCXLIX. On the equilibrium being deſtroyed, the air invariably deſcends in every direction to that place where it meets with leaſt reſiſtance (CCXLVII.) But air that is denſe and heavy deſcends more eaſily than that which is light, whoſe force ſcarcely exceeds that of the air in the lungs, nor is able by the ſame force to overcome the reſiſtance of the bronchia, and of the force by which the air contained in the lungs is compreſſed. Hence an animal lives with greater eaſe in a denſe than in a light atmoſphere: although that air is always better tolerated, which

which is pure in proportion to its levity; ſuch as that of the higheſt mountains of the Alps. Therefore, that the air may enter the lungs, they muſt make a leſs reſiſtance to it than before; namely, the air, which is already in the cellular fabric of the lungs, muſt be rarefied: but this effect will be produced, if the cavity of the breaſt, which is filled by the lungs, be dilated. The air, which is always in the lungs, expands into this increaſed ſpace, by which, being weakened in its ſpring, it makes leſs reſiſtance to the external air; conſequently a portion of external air deſcends into the lungs, ſufficient to reſtore to the air, now contained in the lungs, the ſame denſity with that of the external air.

CCL. We muſt, therefore, deſcribe the powers which dilate the breaſt. The breaſt or thorax is compoſed of bones, muſcles, and cartilages; being almoſt of the ſhape of an elliptic barrel, ſomewhat compreſſed before, but behind divided by an eminence, whoſe hoops are the ribs, and of remarkable ſtrength. In the lateral parts of this ſtructure, the lungs are ſituated; the central and lower parts contain firſt the pericardium, and then ſome of the abdominal viſcera.

CCLI. The baſis of the thorax is formed by a column, a little curved, at the upper part gibbous backwards, ſo that its ſummit is ſituated moſt behind. To this twelve vertebræ are affixed. But they alſo coaleſce, by the union of their bodies into a ſingle column, which projects forwards between the two cavities of the breaſt; divides the right from the left; and is plain in the forepart, and broad towards the ſides. A ſlight ſinuoſity receives the ribs into that place where the arch ſeparates from the body. They are bound together into one column, both by the elaſtic plate interpoſed between the bodies of every two, and coaleſcing with both; and by other ligaments and ſpines lying upon

on one another, and by the junction of the ribs; on which accounts they ſcarcely admit of motion amongſt themſelves. The ſides of the breaſt are formed of twelve ribs. Theſe are in general bent in the form of an irregular arch, having a conſiderable curvature laterally and backwards, but extending in their forepart towards a right line. The bony parts of the ribs are, however, parallel with each other. The greateſt part of the rib is bony; of which the poſterior portion is round and thick, and the anterior thin and flat. The anterior remaining part of the rib conſiſts of a cartilage; which in general preſerves the figure of the rib, broad, flat, adhering to an irregular hollow of the bony part; and which does not change into bone, unleſs in extreme old age.

CCLII. The poſterior, bony, and thick part of each rib terminates in a head. Theſe are inſerted into pits ſcooped out of the bodies of the uppermoſt and two lowermoſt vertebræ, and in the contiguous margins of each of the other two. The vertebræ are tied to the ribs by ſtrong ligaments, of which the principal is diſtributed upon each adjacent vertebra, in a radiated manner from each rib; other ligaments tie the tranſverſe proceſs to the tubercle of the rib, and others connect the contiguous ribs, and alſo the tranſverſe proceſſes, with each other. Moreover, between the angle of incurvation and the articulation with the vertebræ, each of the ten upper ribs has a tubercle, which, being connected with the plain ſide of the tranſverſe proceſs of the correſponding vertebra, are tied by ſhort and ſtrong ligaments to that proceſs, in ſuch a manner, that, while the juncture is very ſtrong, the rib can aſcend and deſcend for a ſhort way.

CCLIII. Of the anterior cartilages, the ſeven uppermoſt reach to the ſternum, and ſtrengthened by ſhort ligaments, they enter with a double head into lateral depreſſions in that bone, which are incruſted with

cartilage,

cartilage. Of the five remaining ribs, the uppermoſt is agglutinated by ſtrong cellular ſubſtance to the ſeventh, and each lower one to the one immediately above it, ſo that they form a continuous margin, which is itſelf faſtened to the ſternum. The cartilages are connected with each other both by proper ligaments, and by cartilaginous appendages joined by cellular ſubſtance: the two lowermoſt are free, and connected only with the muſcles. Theſe inferior cartilages are united to one another and to the ſternum by ſtrong ligaments.

ccliv. The firſt rib is the ſhorteſt and moſt ſolid. As they follow in ſucceſſion to the ſeventh and eighth, every two of them form larger and more moveable circles. The eighth is the longeſt of all; and below it, they always become ſhorter, the lower they are.

cclv. The upper rib deſcends; the ſecond joins the ſternum almoſt at a right angle, while the others aſcend both to the vertebræ and to the ſternum, but more to the latter. The bony part of the ribs is placed in ſuch a direction, that the uppermoſt have their anterior ſurface declined forwards, almoſt tranſverſely. About the third rib it is placed almoſt perpendicularly; and below the middle ones, it projects a little forwards. Beſides, the ſtrength of the ribs is very different. The uppermoſt, being ſhort, tranſverſe, rather united than articulated with the ſternum, and, laſtly, often conſolidated, make the greateſt reſiſtance. The mobility of the lower ribs increaſes ſucceſſively to the loweſt, which, adhering only to muſcles, moves moſt freely of all.

cclvi. The ſternum in general is a thin ſpongy bone, in adults of a ſingle piece, but in the fœtus variouſly multiplicate. Its upper part is broader, octagonal, and ſupported by the clavicles, which are united with it by a triangular head, and very ſtrong articulation, and by the firſt rib on each ſide.

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The next part which is longer and narrower, grows broader downwards, and its ſides receive the ribs into proper angular cavities. The lower part, which is leſs and ſhorter, is obtuſely ſhaped like a tongue. This is continued into a detached appendage, partly bony, and partly cartilaginous, which is called the enſiform cartilage; of various ſhapes, being ſometimes obtuſe like a little tongue, ſometimes pointed, ſometimes bifid, and ſometimes perforated.

CCLVII. In order, therefore, to dilate the ſeat of the lungs, and thus to produce that condition which cauſes the external air to deſcend into the lungs, the thorax muſt be elevated. For thus all the ſections of the thorax form right angles, and its capacity is increaſed. This motion is performed by various muſcles, which either operate conſtantly, or only at certain times. The whole of the intercoſtal muſcles, always elevate the ribs. Under this name we comprehend 22 muſcles; of which 11 are external or ſubcutaneous; and as many internal, ſeparated from the pleura only by fat and cellular ſubſtance. The origin of the external intercoſtals is at the poſterior articulation of the ribs (CCLII.) their anterior termination is in the bony part of each rib, at ſome diſtance from the cartilage, ſo that the remaining ſpace between the cartilages, all the way to the ſternum, in place of the muſcles, is filled with an aponeuroſis. Their direction is ſuch, that they deſcend obliquely forwards, from the lower edge of the upper rib to the upper edge of the lower rib. Almoſt all authors agree, that they elevate the ribs; becauſe they deſcend from the upper and more fixed, to the lower and more moveable rib, in ſuch a manner, that their lower point lies more diſtant from the vertebral articulation, or fulcrum of the lever of the ribs.

CCLVIII.

ccLVIII. But the internal intercoftals arife at fome diftance from the vertebræ, near the outfide of the tubercles (ccLII.) From thence they proceed as far as the fternum, into which the firft of this kind are inferted above. Except the anterior part of the firft internal mufcles, their direction is contrary to that of the former; fo that they defcend backwards, from the lower margin of the upper rib, to the upper edge of the lower rib. Therefore their action is difputed, becaufe their lower infertion is made into a point of the rib, nearer its articulation with the vertebræ, which, therefore, feems to be the leaft moveable: however, they elevate the ribs notwithftanding this; for the immobility of the upper rib, arifing from its articulation, weight, and ligaments, far exceeds the mobility produced by its greater diftance from the fulcrum. This is proved by the diffection of living animals; in which it appears, that the internal mufcles act during the elevation of the ribs, and reft when they are depreffed; by threads fixed to a flexible human fkeleton, and drawn in the direction of the internal intercoftal mufcles, which always and invariably raife the inferior rib towards the fuperior; and by the firmnefs of the upper ribs, which ferve as a fixed point to the lower ones: for the firft ribs are from eight to twelve times lefs moveable than the other true ribs; while the difference of diftance from the centre of motion, is fcarcely the twentieth part of the whole lever. And laftly, by experiment on the dead fubject; for, on raifing its thorax, the internal intercoftals fwell.

ccLIX. By the action, therefore, of thefe mufcles, the thorax is elevated, not altogether as one machine, nor would refpiration be affifted by fuch a motion; but the ribs, turning upon their articulations, behind are but little moved, while with their anterior extremities, they defcend and form larger angles both with the fternum and vertebræ;

and in the middle of their arches, they aſcend and raiſe their lower edges forwards. At the ſame time, the ſternum is thruſt forward from the vertebræ and from the junctures with the ribs. Thus the ribs are both farther from the vertebræ, and the right ribs recede from the left; and both diameters, from the right to the left, and from the ſternum to the vertebræ, are increaſed by almoſt two lines each; and as this occurs in every imaginable ſection of the thorax, the cavity of the breaſt will be ſufficiently dilated. This happens eſpecially in women, and in men whoſe breathing is ſomewhat laborious. Theſe effects are produced leaſt of all by the firſt ribs, but more by the ſucceeding ones. In ſtrong inſpirations, the ribs deſcend both behind and before, and, along with theſe, the ſternum; and the ſpaces between the cartilages are leſſened. But this dilatation is neither ſufficient for healthy reſpiration, nor is it almoſt obſervable in men; although even then, the intercoſtal muſcles, by retaining and elevating the ribs, very much aſſiſt the inſpiration in a ſecondary way, by affording a fixed point to the diaphragm, ſo that the whole force of that muſcle may be ſpent, not in depreſſing the ribs, but in lowering itſelf. The greater part, therefore, of the ſpace which the thorax gains in inſpiration, ariſes from the action of the diaphragm.

CCLX. By the diaphragm we underſtand a muſcle expanded in a curvilineal plate, which, in general, ſeparates the pulmonary bags from the abdomen in ſuch a manner, that the middle and tendinous part is the higheſt, and ſupports the pericardium; that the lateral portions, which ariſe from the ſolid parts of the thorax and loins, are every where lower; and that its poſterior portions are loweſt of all. The fleſhy fibres of this muſcle ariſe from the internal or poſterior ſurface of the enſiform cartilage to the very point, and from the ſixth, ſeventh, eighth, ninth, tenth, eleventh ribs,

and

and apex of the twelfth ; after which follows an interval, in which the naked pleura is contiguous to the peritonæum. Thereafter mufcular appendages of the diaphragm, much ftronger, collected into two, three, or four round mufcles on each fide, arife flefhy from the tranfverfe procefs of the firft lumbal vertebra, and from the fide of the body of the fecond ; and tendinous from the middle of the body of the fecond, third, and fourth, and from the cartilages placed between them, on the whole higher up in the left fide, and lower down in the right.

CCLXI. All thefe fibres (CCLX.) becoming tendinous, form the centre of the diaphragm, which refembles, in figure, an obtufe gnomon, and fupports the pericardium with its middle and broader angle, while the lateral wings, of which the left is narrower, defcend backwards. This central portion is more moveable than the reft ; but in the middle tendinous part, and neighbouring mufcular fubftance, it is refifted by the heart ; the lateral wings and contiguous portions are the moft moveable. The fibres of this tendon form a moft beautiful web, principally indeed on the upper part ; which ftretches from each mufcular portion, to the mufcular portion oppofite to it : and then they form remarkable inferior fafciculi, tranfverfe, right, left, and pofterior, which laft portion is the uppermoft.

CCLXII. There are two holes in the diaphragm ; of which the right, in the right fide of its tendon, is obtufely fquare, and circumfcribed by four ftrong tendinous fafciculi ; the left, which is elliptical, lies betwixt the right and left flefhy portions, arifing from the middle of the bodies of the lumbal vertebræ : under this opening they decuffate and crofs each other once and again, but above they end in the tendon. Therefore it is probable that the latter is contracted during the action of the diaphragm, and that the former remains immoveable.

able. For tendons are but little changed during muſcular motion.

CCLXIII. The ſtructure of the parts, and the diſſection of living animals, demonſtrate, that the fleſhy portions of the diaphragm, by aſcending on all ſides from fixed points to middle and moveable parts, depreſs theſe, and by that means draw downward the lateral bags (LXXVII.) of the thorax, which contain the lungs; and thus augment the perpendicular diameter of the breaſt. The muſcular portions are more depreſſed; the tendon leſs, both becauſe it is fixed to the pericardium, and becauſe its own ſubſtance does not contract. The œſophagus and even the vena cava are compreſſed, while the diaphragm acts. The diaphragm almoſt alone performs the office of reſpiration in a healthy man who is at reſt; and alſo in thoſe whoſe ribs are fractured, or the ſternum burſt, or where the perſon will not make uſe of his ribs on account of pain. The force of the diaphragm alſo, in dilating the breaſt, is greater, according to calculation, than all the reſt of the powers which contribute to reſpiration. The extent of an inſpiration is thus far limited, becauſe, during the extreme action of the diaphragm, the lower ribs are drawn inwards, and the breaſt is ſo far ſtraitened. To oppoſe this, the intercoſtal muſcles interfere in a moderate inſpiration; in an exceſſive one they are not equal to the diaphragm. The phrenic nerve, when irritated, more evidently than in moſt other muſcles, forces the diaphragm to perform its office. The lungs themſelves are entirely governed by the air, ribs, and diaphragm; being in immediate contact with theſe, as appears through a large inciſion, or through the pleura, or pellucid part of the diaphragm, when the containing parts remain entire.

CCLXIV. In violent inſpirations, occaſioned by an increaſed quantity of blood driven into the lungs,

lungs, or by any obſtacle occuring in them, ſeveral other powers elevating the thorax, aſſiſt in dilating the breaſt, which are inſerted into the thorax, clavicles, or ſcapulæ; ſuch as the ſcaleni muſcles, maſtoidei, trapezii, cervicales deſcendentes, ſerrati ſuperiores, pectorales, and levatores parvi, for which anatomy muſt be conſulted.

CCLXV. Thus, there are powers which increaſe the capacity of the thorax in all its three dimenſions (CCLXIII. and CCLIX.) By theſe the cavity of the breaſt is dilated, ſo that it compreſſes the lungs leſs than before: into that ſpace the lungs ſtrive to extend themſelves, ſince they are never deſtitute of air, which, as ſoon as the preſſure is taken off, becomes rareſied, and expands itſelf. Independent of the action of the muſcles, the lungs poſſeſs no peculiar inherent power of attracting air: and, even when they are moſt full of air, on cloſing the trachea, the animal, however, attempts to inſpire, by the efforts of its intercoſtal muſcles and diaphragm. It follows, that the air (CCXLVII.) gravitating, and preſſed on all ſides by the incumbent columns of the atmoſphere, muſt enter the thorax; and with greater force the leſs air is in the lungs; and with the greateſt, if they contain no air: but air will not enter the thorax, if the air, being admitted to the lungs through a wound in the breaſt, compreſs their ſurface. In this action, therefore, which is called inſpiration, the bronchia are every way increaſed, both in length and breadth; becauſe all the diameters of the thorax are increaſed, and the inflated lungs remain immediately contiguous to the pleura. At the ſame time, the veſſels, which are joined with the bronchia by a cellular ſheath, become longer and are extended, and the ſmall angles become larger; by which means, the circulation is facilitated. Beſides, when the veſicular ſubſtance of the lungs is filled with air, the ſpace through which the capillary

lary veſſels of the lungs run, is increaſed, the branches of the arteries and veins are ſtretched out at greater angles, the lobes preſs leſs upon each other, the compreſſion of the neighbouring parts is leſſened, and, therefore, the blood ſent from the heart will flow with greater eaſe and celerity through the large and ſmall arteries of the lungs. Hence, by inflating the lungs, and by that means facilitating the paſſage of the blood to the left ventricle, moribund animals are reſuſcitated, and in the ſame way perſons who are taken out of the water apparently drowned. But, on account of its great levity, the preſſure of the air upon the blood does not deſerve notice, as being three hundred times leſs than the force of the heart; and inſufficient to force the air againſt the blood, which may eaſily be done by a ſyphon.

cclxvi. Is air contained between the lungs and the thorax? Is this air rarefied in inſpiration, and afterwards becoming condenſed, and compreſſing the lungs, does it cauſe exſpiration? Is this opinion confirmed by the analogy of birds, of which it is ſtrictly true? Every thing concurs to confute this opinion: behind the pleura, in living quadrupeds, as well as in dead human bodies, the naked lungs are viſible, without any intermediate ſpace betwixt them: on perforating the pleura, the lungs retract themſelves towards the vertebræ, as ſoon as the air comes in contact with them. In birds, the lungs, being pervious, admit the air through large holes into the cavity of the thorax. But in theſe there is a manifeſt ſpace betwixt the lungs and the pleura, which would be equally manifeſt in quadrupeds, if the lungs were not contiguous with the pleura. Large wounds, admitting the air into one cavity of the thorax only, diminiſh the reſpiration; but ſuch wounds, as let the air into both cavities, ſuppreſs it. When the thorax is opened under water, it emits no bubbles of air through the ſaid water;

water ; but in birds, in whofe thorax there is air, it does. The imaginable fpace betwixt the lungs and the thorax is filled by vapour, or a very little water. Adhefions of the lungs injure the refpiration but in a fmall degree ; which ought entirely to ceafe, if any intermediate air betwixt the lungs and thorax were neceffary to refpiration. Finally, the external air, being admitted to any of the membranes of the human body, inflames them, if they be not defended by plentiful mucus, and of this the pleura is deftitute.

CCLXVII. Refpiration, whether by the admixture of a fubputrid vapour, or in fome other way, certainly vitiates the air, and renders it unfit either for inflating the lungs or fupporting flame ; and laftly, it deprives that element of its elafticity. It is probable that this happens from putrefaction, fince, by a crowd of men the air is rendered peftilential, and fevers of the moft malignant kind are generated in a few hours. In whatever way it happens, we are certain, that, in the lungs, the air is vitiated ; lofes its elafticity ; and cannot keep the lungs diftended, fo as to tranfmit the quantity of blood now increafed by the dilatation of the pulmonary arteries, into the veins. Nor can the will dilate the breaft beyond certain bounds, or affift the paffage of the blood. A ftate therefore will take place, in which the blood cannot pafs through the lungs.

CCLXVIII. Thus a new refiftance to the blood continually coming from the heart is generated : and in long retentions of the breath, as in making violent efforts, the venous blood, efpecially of the head, ftagnates before the right ventricle of the heart, which is clofed up, becaufe it cannot evacuate itfelf into the lungs ; and tumefies the face with rednefs, and fometimes burfts the veins of the brain, neck, inteftines, kidneys, or lungs, and even the right auricle of the heart. This is the caufe of

exceffive

exceſſive anxiety of mind; this is the cauſe of death in compreſſed air, in perſons drowned or ſtrangled, which is much more ſudden than is commonly imagined with regard to drowned people. A living perſon therefore, that he may remove thoſe inconveniencies which ariſe from the paſſage of the blood being obſtructed, ſlackens the powers of inſpiration, and excites to action thoſe of exſpiration, in order to free the breaſt from the too greatly rarefied air.

CCLXIX. Theſe powers are, firſt, the elaſticity of the ribs, which being drawn upwards out of their natural ſituation, as ſoon as the elevating powers ceaſe to act, ſpontaneouſly replace themſelves at more acute angles with the ſternum and vertebræ. There is alſo the elaſtic force of the bronchia and veſicles diſtended with air, by which they endeavour to contract. Hence exſpiration is performed more eaſily and quickly than inſpiration; and hence it is the laſt action of dying people.

CCLXX. Theſe are aſſiſted by the abdominal muſcles; the oblique, ſtraight and tranſverſe. The former of theſe are faſtened by one part to the lower ribs; and by another part, they are attached to the os pubis and ilium, which are immoveable, when compared with the breaſt. Therefore, the ſtraight muſcles, being contracted, flatten the arch into which the abdominal viſcera were protruded by the depreſſion of the diaphragm, reduce the convexity of the abdomen nearer to a ſtraight line; force the abdominal viſcera upwards and backwards againſt the diaphragm, which alone can give way; and preſs it up into the thorax, which is thus rendered ſhorter. The oblique muſcles, for the ſame reaſons, compreſs the lateral parts of the abdomen, carry the liver and ſtomach backwards, and preſs them towards that place where there is the leaſt reſiſtance. Laſtly, all of them draw down the ribs which were elevated by the intercoſtals. The

tranſverſe

tranfverfe mufcles, indeed, do not draw down the ribs; but they pull the cartilages of the falfe ribs a little inwards, render the whole abdomen much narrower, and force the fame vifcera againft the diaphragm. As acceffory powers may be reckoned the fternocoftal, and the long internal intercoftal mufcles, which are called depreffors. By this joint force the elevated ribs defcend; the middle ones more, the uppermoft lefs, the loweft moft of all; their margins are drawn inwards; the cartilages afcend, and return into acute angles with the fternum; and the fternum itfelf recedes backwards with the ribs. By thefe means the thorax, by the converfe of CCLIX. is rendered narrower in every direction and fhorter, and expels as much air out of the lungs as is fufficient to remove the uneafinefs (CCLXVIII.)

CCLXXI. In violent refpiration, when the infpirations are fuller, the more powerful exfpirations derive affiftance from fome other caufes, as the facrolumbalis, longiffimus and quadratus mufcles. By this force, leaden bullets, weighing above a dram, may be blown to the diftance of 363 feet; which force is equal to a third part of the preffure of the atmofphere. But, in a healthy perfon, the mufcles of the abdomen alone fuffice, and the lungs are not fo much emptied as in blowing.

CCLXXII. The effects of exfpiration are the compreffion of the blood-veffels of the lungs; the diminution of the angles of the bronchia; the refting the weight of the adjacent veffels on the reticular veffels; the expulfion of the corrupted air from the lungs; the propulfion through the veins of that part of the blood which is impacted in the capillary arteries, to the left fide of the heart, and the impeding that part of the blood which is coming from the right ventricle. Exfpiration, therefore, ftops the ready entrance of the blood into the lungs; and as the whole thorax is compreffed at the fame

time,

time, it repels the venous blood into the veins of the head, and fills the brain and its ſinuſes.

CCLXXIII. In this manner the neceſſity for reſpiration ariſes anew, as often as the collapſed veſſels of the lungs reſiſt the blood expelled from the right ventricle of the heart: this is one cauſe of death in thoſe animals which expire in veſſels exhauſted of air. The lungs in thoſe which have remained long in vacuo, from having the air drawn out from them, become denſe, ſolid, and heavier than water; and, therefore, impervious to the blood. Of the ſame kind is the death of thoſe who are killed by lightning, and perhaps by the noxious vapours of caverns. Therefore, in conſequence of a moſt intelligent ſtructure, at the firſt perception of the uneaſineſs ariſing from the oppoſition to the paſſage of the blood through the lungs, the exſpiring powers become relaxed, the inſpiring powers are excited into action, and the motion of the blood through the lungs is rendered free and accelerated.

CCLXXIV. Are there other cauſes of alternate reſpiration? Is any thing to be derived from the compreſſion of the vena ſine pari, of the phrenic nerve, or from the blood not being ſent to the brain? But theſe are diſproved by comparative anatomy; which, where there is no ſuch nerve or vein, finds the ſame alteration in reſpiration every where. Does it proceed from the alternate contraction of antagoniſt muſcles, among which, thoſe of exſpiration relax thoſe of inſpiration, and the reverſe? But, according to this argument, all the muſcles of the human body would be perpetually alternating in their motions.

CCLXXV. From what has been ſaid, it ſufficiently appears, that reſpiration is abſolutely neceſſary to a healthy adult; becauſe, whether the lungs remain long in a ſtate either of exſpiration or of inſpiration (CCLXXIII. CCLXVIII.) death will be the conſequence.

confequence. Therefore, no animal, that has lungs like ourfelves, after it has breathed for fome time, fo that the air fhall have penetrated into the inmoft parts of the lungs, and the pulmonary artery fhall have brought a new quantity of blood to that vifcus, can fubfift longer than a few minutes without the ufe of air, without perifhing, or at leaft falling into a ftate which differs from death only in the poffibility of recovery. In an animal recently born, this neceffity for air does not take place very inftantaneoufly.

CCLXXVI. But the ufe of refpiration is different from this neceffity; which nature might have avoided, either by forming no lungs at all, or by conftructing them fimilar to thofe of the fœtus. The ufe, therefore, of refpiration, muft be very confiderable, fince all animals are furnifhed either with lungs, or with gills, or with a windpipe diftributed through all parts of the body.

CCLXXVII. To inveftigate this utility, let us compare the blood of the adult with that of the fœtus, and with the vital fluid in fifhes. It appears, that in the fœtus the blood is deftitute of its florid rednefs and folid denfity; that the blood of fifh is cold, and has lefs denfity, and a tender craffamentum. It is therefore probable, that the blood acquires both thefe properties in the lungs.

CCLXXVIII. Is animal heat generated principally in the lungs? Does it arife from the alternate extenfion and contraction, relaxation and compreffion, of the veffels (CCLXV. and CCLXXII.) by which the folid parts of the blood are perpetually rubbed together, and fuffer attrition from their conftriction? The lungs, therefore, will add to the office of the reft of the arteries, becaufe in them the blood is alternately relaxed and compreffed more than in any other part of the body. But when the lungs are obftructed, ulcerated, and almoft deftroyed, morbid heat is increafed in the human body: and in the lungs,

lungs, the cold air comes moſt nearly in contact with the blood.

CCLXXIX. The denſity is, indeed, promoted by the copious diſcharge of watery vapour from the veſſels of the lungs, by which the reſt of the maſs becomes ſpecifically heavier. In the ſame manner as in other arteries, the blood, being alternately retarded and accelerated, is figured by the moulds of the ultimate arteries, becomes ſpherical, and therefore denſer, having more ponderous globules, and leſs light fluid. The pulmonary vein alſo being ſmaller than its correſponding artery, is of conſiderable uſe in compreſſing the globules, and in increaſing their attraction. Nevertheleſs, cold animals, with very ſmall lungs, have denſe and coagulable blood; as alſo the chick in ovo. The courſe of the blood through the lungs is ſhorter: through the whole body the courſe is longer, and the artery weaker; the ventricle, by which the blood is propelled, is alſo weaker.

CCLXXX. Is the air itſelf received into the blood in the lungs, and does it there produce neceſſary vibrations? Is this demonſtrated from the reſiſtance of the body to the weight of the external air; from the air found in the blood-veſſels, in the cellular ſubſtance, and in the cavities of the human body; from the cracking produced by extending the joints; from air being manifeſtly poured from the trachea into the hearts of many animals, as the locuſt: from the eſcape of air from the blood and animal fluids in Mr. Boyle's vacuum; from the neceſſity of a vital oſcillation in the blood; and from the increaſed redneſs of the pulmonary blood?

CCLXXXI. That no elaſtic air is here received into the blood, is demonſtrated from its not being able to enter into the blood, if it retain its elaſticity; from the inutility of its reception, if its elaſticity be loſt in the blood; from the perfect immutability of the blood by cold; from the minuteneſs of

of the inhaling veſſels; from the ſides of the veſicles being perpetually covered with mucus; from the elaſtic nature of air being unfit to paſs through capillary veſſels; and from its repulſion by water, that hinders it from paſſing through moiſtened paper, linen, or leather. Again, air thrown into the trachea never paſſes into the heart; or only when it is driven with exceſſive force. In the veſſels and humours of the human body, air, from a ſtate of inelaſticity, becomes elaſtic in conſequence of putrefaction, froſt, or an external vacuum. But ſuch air exiſts in every liquid, and is taken into our bodies with the aliments, and with vapours, mixing ſlowly and difficultly. There never were any elaſtic bubbles of air obſerved in the blood of a living animal, unleſs after wounds; air being inflated into the blood-veſſels of any animal, kills it certainly and ſpeedily. Nor is there any thing ſufficiently certain in the increaſed redneſs of the blood in the pulmonary veins. Laſtly, air indeed is abſorbed by moſt fluids, and by water, but ſlowly, and only at the end of ſeveral days after the former air has been exhauſted by the pump. It then likewiſe lays aſide its elaſtic nature; and no reaſon has been advanced why the air ſhould either be more ſpeedily abſorbed by the blood, or why it ſhould retain its elaſticity after its abſorption.

cclxxxii. Is the blood cooled in the lungs? Is this proved from the death of animals in air heated to the ſame degree with the animal, as is believed to have happened from very ſultry ſummer weather, and ſcorching eaſt winds? Are the pulmonary veins, therefore, leſs than the arteries? Does the deſire of cold in hard working people ariſe from thence? That the blood is cooled in the lungs, is thus far true, that it warms the contiguous air, and therefore imparts to it ſomething of its own heat. But that this was not the deſign of nature, is evident; ſince no one has ſaid, that the venous blood

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is hotter than the arterial, although ſome aſſert that it is colder; and nobody ever obſerved the left ventricle of the heart colder than the right. But the venous blood enters the lungs. If it be cooled there, it follows that the arteries muſt receive it ſtill colder. Therefore, the blood recovers that heat which it loſt, and even more: and beſides, a perſon may live in an air much hotter than the blood itſelf, of which we have a familiar example in baths, and warm climates. The ſize of the pulmonary artery in the fœtus, which does not reſpire, is greater; and the larger area of the right auricle and ventricle of the heart, which is likewiſe much greater in the fœtus, ſeems to be a receptacle ſubſervient to frequently neceſſary retardations, and the narrowneſs of the vein contributes to the acceleration of the blood.

CCLXXXIII. Does the blood derive its redneſs from the air? This is contradicted by what we ſee in cold animals, which, though they make almoſt no uſe of the air, have blood equally red with that of warm animals; by the certain connection of redneſs in the blood of frogs, with their having plenty of food, and of paleneſs with want of food; and by the air, as we have juſt now ſaid, having no acceſs to the blood. Nevertheleſs, redneſs is produced, and reſtored to the blood by the contact of air, and is deſtroyed by its removal. Does ſome ſubtle element from the air penetrate the blood, and cauſe its colour, as light is required for the colours of plants?

CCLXXXIV. Is the uſe of the lungs, to abſorb nitre from the air to the blood? Is this the cauſe of the florid colour, obſervable on the ſurface of a cake of blood, while the bottom part is black. Does this preſerve the animal from putrefaction? It is certain, that ſome volatile principle of acidity exiſts in the air, which, with a ſuitable earth, forms nitre; for nitrous earth, after being exhauſted, when

when expoſed again to the air, becomes reimpregnated with nitre. But the ſame principle of acidity, we know by certain experiments, with different earths, forms a vitriolic ſalt, or alum, or ſea-ſalt. For the caput mortuum of ſea-ſalt, which remains after the diſtillation of the acid, recovers from the air the property of furniſhing more acid by diſtillation; and in ſnow, there is cubical ſalt: from marcaſites, true vitriol exudes; and colcothar recovers the acid, which was drawn from it, and alkali becomes vitriolated tartar. Is this, therefore, the uſe of reſpiration? The quantity of theſe ſalts, which exiſts in the air, is too ſmall; and reſpiration is moſt ſalutary on the higheſt mountains, where they are moſt rare; nor have any marks of a nitrous ſalt ever been detected in our blood.

CCLXXXVI. Why do tortoiſes, frogs, lizards, ſnails, earwigs, and many other inſects, live long without air? In them, the lungs are given, not ſo much for the preparation of the blood, of which they have but a ſmall quantity, as for aſſiſting them in ſwimming; hence their lungs are ſupplied with veins from the cava, and with arteries from the aorta. Inſects inhale and exhale air, through points in the ſkin. Why do all animals, however ſmall, ſuch as little birds, periſh in air that is not renewed? Becauſe the air, which has once entered the lungs, is contaminated by inelaſtic, watery, and alkaline vapours, and therefore it becomes noxious: not becauſe it becomes lighter; for the mercury falls but little in air, which has not been renewed, and which has killed an animal. Hence, on the other hand, animals ſurvive longer in air which is more compreſſed than that of the atmoſphere: for in that caſe, the proportion of the elaſtic element is greater, and therefore the air is more ſlowly contaminated. But, even in other caſes, confined air becomes deleterious, and filled with vapours, by ſtagnation alone. Why do animals ſwell in an exhauſted re-

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ceiver? From the expanſion of the air, which exiſted in an inelaſtic ſtate in the blood.

CCLXXXVII. There is a certain connexion between the pulſe and reſpiration. According to the common courſe of nature, three or four pulſations are reckoned to one reſpiration. If the quantity of blood ſent to the heart be increaſed, the frequency, both of the pulſe and reſpiration, are increaſed. This is the reaſon of the panting in a perſon, taking exerciſe, which accelerates the motion of the venous blood (CXLII.) If the blood meet with much reſiſtance in the lungs, and do not paſs freely from the right into the left ventricle of the heart; to accelerate its courſe, both the number and magnitude of the reſpirations are increaſed. This is the cauſe of ſighing, yawning, and panting; of which the firſt is a deep inſpiration; the ſecond ſlow, and very great; and the third, frequent and imperfect. The number of reſpirations, however, does not always increaſe with the pulſe; of which we have an example in fevers, in which the lungs are not affected.

CCLXXXVIII. The mucus, which lines the ſenſible membrane of the bronchia, may become troubleſome, both by its quantity and acrimony; it has been even known to cauſe ſuffocation in a dropſy of the lungs. Therefore, its ſuperabundance, adheſion, or acrimony, is removed by coughing; namely, by irritating the reſpirative ſyſtem, the mucus or concretions are looſened and expelled by large inſpirations, and exſpirations, alternately ſucceeding each other with rapidity, and by ſtrokes of the abdominal muſcles.

CCLXXXIX. Laughter differs from coughing in its cauſe, which reſides commonly in the mind, or at leaſt conſiſts in the titillation of ſome of the cutaneous nerves; and alſo, becauſe, after one deep inſpiration, there are frequent but imperfect exſpirations, through the contracted glottis, and the air is

not

not totally evacuated from the lungs. Hence laughter, in a moderate degree, conduces to health; because, in place of one full inſpiration, ſeveral inſpirations and exſpirations happen in the ſame time, and thus the concuſſion is greater. Hence its danger, from ſtagnation of the blood; becauſe the exſpiration is not full, and therefore the blood is admitted into the pulmonary artery, but is not ſuffered to paſs through it. Weeping begins with a deep inſpiration, after which follow ſhort alternate inſpirations and exſpirations; and it is finiſhed with a deep exſpiration, which is immediately followed by an inſpiration: hence it has nearly the ſame good and bad effects; and, when moderate, it relieves the diſtreſs ariſing from grief. Hiccough is a very great, ſonorous, and ſudden inſpiration. Sneezing conſiſts of one deep inſpiration, ſucceeded by a ſingle powerful exſpiration; and by the torrent excited, the acrid matter, irritating the noſtrils, is blown away.

CCXC. The ſecondary uſes of reſpiration are very numerous. It exhales copiouſly, and removes from the blood ſomething highly noxious; for by remaining in the air, it will cauſe ſuffocation; and the breath of many people, crowded in a cloſe and ſmall place, impregnates the air with a ſuffocating quality. On the other hand, it abſorbs from the air a thin vapour, of which the uſe is perhaps not ſufficiently known. It is alſo a force, which perpetually compreſſes the abdomen, and all its viſcera; it evacuates the ſtomach, inteſtines, gall bladder, receptacle of the chyle, urinary bladder, inteſtinum rectum, and the womb; it comminutes the aliments, and forces the blood through the liver, ſpleen, and meſentery. It cauſes a kind of flux and reflux in the blood, ſo that it is alternately preſſed back towards the extremities of the veins, and a little after is propelled towards the heart by an accelerated velocity, as into an empty ſpace. Moreover, inſpi-

ration attracts the odoriferous particles from the air, and conveys them to the ſenſorium. But even ſucking, ſo neceſſary to the new born infant, is effected by inſpiration, and by forming a larger ſpace, in which the air contained in the mouth is rarefied, ſo that the preſſure of the external air forces the milk into that part where it is leaſt reſiſted. Laſtly, the voice itſelf depends upon the air, and ſeems to be the principal manifeſt effect of reſpiration. This, therefore, appears a proper opportunity for deſcribing it.

CHAP. IX.

VOICE AND SPEECH.

CCXCI. THE principal organ of the voice is the larynx; for, when it is injured, the air paſſes through the windpipe, without yielding any ſound. By the larynx, we underſtand an aſſemblage of cartilages, joined into a hollow machine, which receives the air from the fauces, and tranſmits it into the windpipe, connected with it by ligaments and muſcular fibres. Among the larger of theſe cartilages, the annular and ſcutiform in adults oſſify internally. The anterior and larger part of the larynx, which lies almoſt immediately under the ſkin, is compoſed of two cartilages; the thyroid and cricoid, to which the lateral parts of the larynx alſo belong in ſuch a manner, that the portions of the cricoid cartilage always become larger, as they are higher ſeated. The back part of the larynx is compoſed firſt of the ſaid annular cartilage, and afterwards of the arytenoid cartilages, connected by muſcles. The epiglottis, looſely connected with the thyroid cartilage, is either raiſed or inclined over the larynx. The veſſels ariſe from the upper and lower thyroids; the nerves are numerous;

merous; the inferior ones come from the recurrents; the ſuperior ones from the eighth pair, inoſculating in various ways; ſome alſo from the intercoſtal. The former of theſe nerves is remarkable for its origin in the thorax; for its reflection round the aorta and right ſubclavian; for its giving riſe to ſome of the nerves of the heart, and for the experiment, which proves, that the voice is deſtroyed, by tying this nerve.

CCXCII. All theſe cartilages are connected together by various muſcles and ligaments, ſo that the whole may poſſeſs mobility, while ſome of its parts are firm, and others extremely moveable. The ſcutiform or thyroid cartilage, ſituated on the forepart, is compoſed of two, almoſt quadrangular plates, inclined to each other in an obtuſe angle, projecting forwards. In theſe plates, two apertures, one on each ſide for the internal veſſels of the larynx, are found ſometimes, though rarely. The upper proceſſes of this cartilage, terminating in a thick point, inclining upwards and backwards, are connected with the horns of the os hyoides, by ſtrong ligaments, ſometimes mixed with bone. The lower proceſſes are ſhorter, are adapted to the ſlightly hollowed, and almoſt flat ſurfaces of the cricoid cartilage; and are connected by a very firm articulation, on account of the ſhortneſs and ſtrength of the cellular ſubſtance, which unites them. The middle anterior part is joined by ſtrong perforated ligaments, to the middle of the annular cartilage; and likewiſe by other ſuperior ligaments, proceeding from the deſcending horn of the ſcutiform cartilage, to the upper part of the annular cartilage.

CCXCIII. The cricoid cartilage, anteriorly thick and hard, is increaſed backwards, in form of a ring unequally truncated; and, in the middle, it is divided into two cavities by a protuberant line. It is firmer than the reſt of the cartilages, and forms their

their baſis. From it longitudinal muſcular fibres and ligaments deſcend to the windpipe (ccxxxviii.) The pharynx connected with each of theſe cartilages by many muſcular layers, receives the larynx into its cavity. From this cartilage a ſhort ligament proceeds to the arytenoid cartilage on each ſide.

ccxciv. The figure of the two arytenoid cartilages is very complex. It ſpontaneouſly divides into two parts, of which the lower is larger, and is connected by a moderately concave baſe with the thick cricoid cartilage, forming a moveable articulation. It ſends a proceſs forwards, which ſeparates the glottis, and ſuſtains the inferior part of the ventricle of the larynx. They aſcend upwards, of a triangular figure: the poſterior baſe is hollow, and the anterior ſide is convex, and divided by three furrows. They are extenuated upwards, till they are at laſt terminated by a pretty thick, oval, cartilaginous head fixed on them. The lower part of theſe cartilages is connected by numerous muſcular fibres, partly tranſverſe, and partly oblique; of which the different directions are evident, though they cannot be ſeparated. Theſe are called the arytenoid muſcles. In their upper part, the arytenoid cartilages are ſeparated by a perpendicular chink, which has been improperly by ſome called the glottis.

ccxcv. The arytenoid cartilages are connected with the thyroid by tranſverſe ligaments, for the moſt part ſufficiently ſtrong and elaſtic, but covered with the common mucous membrane of the larynx. Theſe ligaments ariſe below the middle of the arytenoid cartilages, and are inſerted into the flat angle of the thyroid cartilage (ccxcii.) and may be ſeparated from each other, by removing the arytenoid cartilages from being in mutual contact, and may be again brought into contiguity by the

cartilages

cartilages approaching each other. This conſtitutes the true glottis, and is continuous, but at right angles with the above mentioned chink (ccxciv.)

ccxcvi. From the ſame angle of the thyroid cartilage, under a notch, from a firm ligament, a cartilage ariſes, with an erect ſlender ſtalk, of an oval ſhape, convex before, behind concave, and with its ſuperior extremity reflected backwards and concave. It is kept erect by its own elaſticity, ſo that it riſes upright behind the tongue ; but it can be ſo inclined whenever the root of the tongue is preſſed backward, that, having become tranſverſe, it completely ſhuts up and protects the paſſage into the larynx, which deſcends between this, the epiglottis, and the arytenoid cartilages. The epiglottis is joined to the tongue by pale membranous fibres, and to the os hyoides by much membranous expanſion. It either has no fibres from the thyro-arytenoidal and arytenoidal muſcles, or they are too minute to counteract its elaſticity.

ccxcvii. At the ſides of the ligaments of the glottis (ccxcv.) two other upper and ſofter ligaments, leſs tendinous or elaſtic, proceed parallel from each arytenoid cartilage to the thyroid. Betwixt theſe two (ccxcvii. and ccxcv.) ligaments of each ſide, a peculiar cavity or ventricle deſcends, having the figure of a compreſſed parabolic ſpace, extending downwards betwixt the double membrane of the larynx, with its ſuperior orifice, of an elliptic form, conſtantly open into the larynx.

ccxcviii. Laſtly, all the internal cavity of the larynx is lined with the ſame ſoft, irritable, mucous membrane, we before deſcribed in the windpipe (ccxxxix.) This membrane is moiſtened by a great number of glands. The uppermoſt are ſmall, and compoſed of ſimple glands (ccviii.) They are ſeated on the anterior convex part of the epiglottis, and ſend prolongations through its various perforations and larger ſinuſes, to its concave ſide, which

which are there continued into ſimilar firm glands. Moreover, upon the anterior furrowed ſurface of the arytenoid cartilages (CCXCIV.) there is on each ſide a gland, of a looſe conglomerate fabric, reſembling much a gnomon, compoſed of round acini, doubtleſs mucous, of which a looſe portion deſcends on each ſide as far as the annular cartilage. In the ventricles, there are numerous mucous ſinuſes. Laſtly, all the internal ſurface of the larynx is full of large mucous pores. All theſe glands ſecrete a thin and watery, but at the ſame time, viſcid mucus.

CCXCIX. Has the thyroid gland any ſimilar uſe? It is of the conglomerate kind, but ſoft, the coverings of the lobules being much more tender than in the ſalival glands, it is very large, is anteriorly ſeated upon the thyroid and cricoid cartilages and windpipe, ſurrounding with lateral productions the ſides of the thyroid, is joined to its companion by an iſthmus, which is narrow and emarginated below; and by a middle very thin proceſs it aſcends on the forepart, almoſt to the os hyoides. This gland is full of a ſerous, yellowiſh, and ſomewhat viſcid humour: Does it diſcharge this fluid into the windpipe, or into the œſophagus? Into neither are ducts certainly known to open. Does it retain its fluid entirely, and afterwards reſtore it to the veins, like the thymus, which is analogous in its ſtructure? Is it a conglobate gland? That the uſe of this gland is very conſiderable, appears from the remarkable ſize of the arteries which it receives from the carotids, and of its inferior ones from the ſubclavians. The veins return into the jugulars and ſubclavians. It has a peculiar muſcle, not however conſtant, ariſing from the margin of the os hyoides, and ſometimes from the lower edge of the thyroid cartilage towards the left, which deſcends without a fellow, and ſpreads its tendinous fibres over the gland, upon which alſo the ſternohyoidei and ſternothyroidei muſcles are incumbent.

CCC.

ccc. The whole larynx is fuſpended from the os hyoides, both by ligaments inſerted into the ſuperior horns of the thyroid cartilage, and by the middle of its baſis, united to the junction of the plates, conſtituting that cartilage. The larynx, and os hyoides connected with it, may be raiſed conſiderably, even half an inch above its mean altitude. This is performed by the biventer muſcles, together with the geniohyoidei, genioglofſi, ſtyloglofſi, ſtylohyoidei, ſtylopharyngei, thyropalatini, hyothyroidei; either conjunctly or partially. During its elevation, the glottis is rendered narrower, and the ligaments before mentioned (ccxcv.) approach nearer together. Thus, by the affiſtance of the action of the arytenoid muſcles, both oblique and tranſverſe, the glottis may be accurately cloſed, ſo as to reſiſt with and incredible force the preſſure of the whole atmoſphere.

ccci. The whole larynx may alſo be depreſſed about half an inch beneath its ordinary ſituation, by the ſternohyoidei, ſternothyroidei, and coracohyoidei, as they are called; and, when theſe are in action, by the anterior and poſterior cricothyroidei. By this motion the arytenoid cartilages remove from each other, and the glottis becomes wider, which is alſo drawn open by the muſcles laterally inſerted into the arytenoid cartilages, and by the cricoarytenoidei poſtici and laterales, and thyroarytenoidei: theſe alſo, by reſting upon the ventricles of the larynx (ccxcvii.) are capable of compreſſing them. The particular cartilages which form the larynx, can ſcarcely be moved ſeparately.

cccii. From the larynx the air comes into the mouth and noſtrils. By the mouth, we here mean that large and irregularly ſhaped cavity, ſituated between the ſoft and hard palates, both concave in the middle, and the muſcles lying under them, and the lower jaw. The noſtrils aſcend forwards above the

the ſoft palate; they are two broad cavities, included between the ſeptum medium, and the oſſa cavernoſa, and ſome other parts. They are every where bony and cartilaginous.

CCCIII. The tongue lies in the middle of the mouth; it is a broad piece of fleſh eaſily changeable into any kind of figure, and readily moved without delay to any part of the mouth: by its own fleſhy fibres, and by the muſcles attached either to itſelf or to the os hyoides, which is joined to it by many fleſhy fibres and membranes, it may with great facility be made to aſſume any poſition or figure. It is drawn forwards by the genioglоſſi and geniohyoidei muſcles; backwards by the ſtyloglоſſi, ſtylohyoidei, ceratoglоſſi, baſioglоſſi, chondroglоſſi, and biventer; downwards, by the ſternohyoidei, and ceratohyoidei; and upwards, by the ſtyloglоſſi, ſtylohyoidei, by the biventers, and likewiſe by the mylohyoidei.

CCCIV. So much for the anatomy. It remains that we demonſtrate what effects are produced by air, when expelled, during exſpiration, by the powers above deſcribed (CCLXIX. CCLXX.) from the lungs through the windpipe into the larynx, and from thence forced through the glottis into the mouth variouſly configured. Theſe effects are, voice, ſpeech, and ſinging. Sound only is produced when the air is expelled with ſo great a velocity through the contracted glottis, that it impinges on the ligaments of the glottis, and thus produces in the larynx that tremor, which, being vibratory on account of its elaſticity, it continues and increaſes. Therefore, from the united vibrations of the ligaments (CCXCV.) and of the cartilages of the larynx, a ſound is produced, which we call the voice, peculiar in every claſs of animals, and which depends entirely on the larynx and glottis. When there are no vibrations, a whiſper is produced.

CCCV.

CCCV. The ſtrength of the voice depends upon the quantity of air exſpired, and the narrowneſs of the glottis; and, therefore, upon capacious lungs eaſily dilatable, an ample, cartilaginous and elaſtic larynx and windpipe, the free reſonance of the noſtrils, and a powerful exſpiration. But the acuteneſs or gravity of the tones, we obſerve to ariſe from various cauſes. The former proceeds partly from the narrowneſs, and partly from the tenſion of the glottis, and the latter from its relaxation and dilatation. For hence, the air, in a given time, impinges upon the ligaments of the contracted glottis with more numerous undulations, and cauſes more frequent vibrations; but when the glottis is dilated, the contrary of all this follows. And from the greater tenſion of the ligaments, the tremors in like manner become more numerous from the ſame ſtroke. Therefore, to produce an acute ſound, the whole larynx is drawn upwards and forwards; and with greater force as the voice is required to be ſharper, inſomuch that the head itſelf is ſometimes inclined backwards, that the muſcles elevating the larynx may exert their full powers. The truth of this is confirmed by experiment, for by applying the fingers to the larynx when acute ſounds are emitted, the elevation of the larynx, which is about half an inch for the octave, is eaſily felt: and by comparative anatomy, which demonſtrates the glottis to be very narrow and cartilaginous in ſinging birds, and wide in hoarſe animals, and ſuch as are low or mute. This is alſo illuſtrated by whiſtling, where the ſharpneſs of the ſound evidently proceeds from the contraction of the mouth: and by muſical inſtruments, in which the narrowneſs of the opening admitting the air, and the celerity with which it is impelled, are the cauſes of an acute tone.

CCCVI. Gravity of the voice is produced by oppoſite circumſtances, the depreſſion of the larynx by

by the caufes (CCCI.) already defcribed; a wide glottis and a very ample larynx. This is proved by the touch, which eafily perceives the defcent of the larynx in perfons finging, in like manner about half an inch for every octave; by the greater gravity of the voice in males, and by the loweft tones of the voice degenerating into a filent breathing.

CCCVII. Does every diverfity of tone proceed from the length of the ligaments of the glottis, which is augmented when the fcutiform cartilage is drawn forwards, and the arytenoid ones backwards? Is it according to this rule, that the moft acute tones are produced, by the ligaments being rendered very tenfe, and therefore vibrating with great celerity? This is afferted by fome late anatomifts, from experiments, which have been alfo repeated by fome eminent men; they have obferved, that, when the chords or ligaments of the glottis are tenfe, the peculiar voice of every kind of animal is produced by blowing air into its trachea; that this voice was rendered more acute by ftretching the ligaments, and more grave by loofening them; that by fhutting the whole ligament, the voice was fuppreffed; by fhutting the half, the voice was rendered an octave higher; by fhutting a third part, a fifth higher, &c. There are not wanting, however, doubts concerning this new theory, arifing from the cartilaginous and bony, and confequently immoveable and inextenfible, glottis of birds; from the certain production of more acute founds, in whiftling, from the mere contraction of the lips; from the example of women, in which the larynx is fofter, but the voice more acute, than in men; from experiments which fhow, that more acute founds are produced by bringing the ligaments of the glottis nearer into contact with each other; and from the total abfence of machinery for ftretching the ligaments, and drawing the thyroid cartilage forwards from the annular

one.

one. But ſince it appears from experiments, that the tenſion of the ligaments ſuffices for producing acute ſounds, without the contraction of the glottis, it is probable that difference of tenſion in the glottis contributes more than a difference of its diameter to the diverſity of voice.

CCCVIII. Singing, is when the voice, modulated through various degrees of acuteneſs and gravity, is expelled through the larynx, while vibrating and ſuſpended between contrary powers, which chiefly diſtinguiſhes it from ſpeech. It is a laborious action, on account of the perpetual action of the muſcles poiſing the larynx; and it increaſes the animal heat, becauſe acute tones require a contracted glottis, which retards the exſpiration, and at the ſame time a great deal of air to give them ſtrength (CCCV.) and, therefore, deep inſpirations are neceſſary. It tends very much to dry the windpipe, from the accelerated paſſage of the air; and renders a great deal of mucus neceſſary, which is the reaſon why there are ſuch numbers of mucous receptacles in the larynx, amongſt which I very much ſuſpect the ventricles before deſcribed (CCXCVII.) ought to be numbered.

CCCIX. Speech is performed when the larynx is at reſt, in tones differing but little in acuteneſs and gravity: by variouſly modifying the voice by the organs of the mouth. Canorous ſpeech has both variations in the tone, and modifications of the voice by the organs of the mouth.

CCCX. All ſpeech is reducible to the pronunciation of letters, which differ in various nations, although they agree in the greateſt number over the whole world. Of theſe, ſome are called vowels, which are expreſſed by the mere emiſſion of the voice through the mouth, without the application of the tongue to any part of the mouth. But conſonants are formed by a colliſion of the tongue againſt ſome part of the mouth, lips, or teeth. The

nature

nature of our work forbids us to be more particular, and prevents us from explaining a moſt ingenious art, which, a rare occurrence in phyſics, has ſo clearly determined all the corporeal cauſes of each letter, that, by mere inſpection and touch of the organs during their pronunciation, it has taught ſpeech by imitation.

CHAP. X.

BRAIN AND NERVES.

CCCXI. THE remaining actions of the human body we ſhall conſider according to the order in which they receive the blood. Of the coronary arteries we ſpoke, when we gave the hiſtory of the heart. Next to thoſe, the carotids ariſe from the aorta.

CCCXII. The aorta, which comes out from the anterior part of the heart (CLVII.) in order to bend itſelf towards the vertebræ of the thorax, inclines backwards, and to the left, in an angle that is round indeed, but not very large, forming a conſiderable arch. From the convexity of this arch, three branches ariſe. The firſt aſcends towards the right ſide, and is immediately ſubdivided into two large arteries, of which the lowermoſt proceeds in the direction of its trunk, under the denomination of the ſubclavian. The other aſcends along the windpipe to the head, and is called the right carotid. The left carotid ſprings next from the ſame arch, a little inclined to the left ſide; and the third, which is ſtill more inclined to that ſide, is called the left ſubclavian, and is ſomewhat leſs than the right. At the origins of theſe branches, the continuous ſide of the aorta is a little thicker, and projects a little to the left. Variations from this courſe are rarely obſerved.

CCCXIII. The carotid artery, inclofed along with the jugular vein and nerve of the eighth pair, in copious and denfe cellular fubftance, commonly arrives at the upper part of the thyroid cartilage, without fending off any branches. There it divides into two trunks. The anterior, which is called the external carotid, is more in the direction of its trunk, and rather larger. It fends off the thyroidea fuperior, the tortuous lingualis, and then the labialis; and from its pofterior part, clofe by its divifion, the pharyngea afcendens, which, befides the pharynx and mufcles of the velum palati, fupplies to the dura mater, through the foramen common to the jugular vein and nerve of the eighth pair, a confiderable branch, fent off at the bafis of the os petrofum, near to the foramen magnum, and cuneiform procefs of the fphenoid bone.

CCCXIV. Then, from the exterior fide of the external carotid, fprings the occipital artery; which alfo fends a branch to the dura mater, which is diftributed, at the bafis of the cerebellum, through a peculiar foramen of the dura mater in the angle which the os petrofum forms by departing from the mamillary procefs: another branch paffes over the atlas to the dura mater, both under and into the fkull; and a third fometimes goes through the foffa jugularis to the dura mater. The next artery, the auricularis, goes to the back part of the ear, to the membrane of the tympanum, and to the temples.

CCCXV. What remains of the external carotid artery, afcends through the parotid gland, to which having given fome branches, as well as to the face and eyelids, it fends out, in the firft place, the temporalis, which is confiderable. The trunk of the carotid, being inclined behind the lower jaw, lofes itfelf under the denomination of maxillaris interna.

In that place, it directly fends off a large trunk to the dura mater, which paffes through a peculiar opening of the broad pterygoid wings, to the

the vicinity of the middle foſſa of the brain; and is largely diſtributed upon the dura mater, in the region of the temples and forehead, as far as the falciform ſinus. Sometimes this artery is double, and often ſends a conſpicuous branch to the lachrymal gland of the eye. Moreover, the ſame maxillary artery enters the upper part of the noſtrils by a triple trunk, where it is ſpent, after having given off branches to the teeth of the lower and upper jaws, the infra orbitalis, a branch to part of the face and eyelids, and the palatine to the bone of the palate, with ſmall twigs to the dura mater, both through the ſmaller pores of the great wings, and accompanying the third and ſecond branch of the fifth pair of nerves, and the dura mater filling up the lower orbital fiſſure.

CCCXVI. But the other trunk, which is poſterior, and commonly called the internal carotid (CCCXIII.) aſcends without a branch. This artery, having firſt made a remarkable ſerpentine flexure, enters through a peculiar foramen in the os petroſum, where it is ſurrounded with a vagina from the dura mater, like that which comes out through all the openings of the ſkull: aſcending upwards, then inclining forwards, it penetrates into the cavity of the ſkull, and aſcends tortuouſly bent along the ſella equina, in the middle of the blood of the cavernous ſinus, having given ſmall branches to the fifth pair of nerves, dura mater, and infundibulum, with one larger to the eye, part of which returns again through a peculiar hole into that part of the dura mater, which lies upon the middle of the orbit. The rete mirabile is peculiar to ſome animals, and does not exiſt in man.

CCCXVII. But the trunk of this internal carotid paſſes over the anterior part of the ſella equina; and being incurvated backwards, and received within the arachnoid membrane, after giving branches to the pons and crura of the brain, and a twig to the

the choroid plexus, and a branch that accompanies the optic nerve, it then divides into an anterior and poſterior branch. The former being conjoined with its fellow artery of the other ſide by a ſhort anaſtomoſis, is then incurvated backwards and upwards, along the corpus calloſum, and goes to the middle and poſterior part of the brain, and ſometimes ſends branches to the falciform proceſs, and at its very origin to the third ventricle, the fornix and thalami. The latter, being joined by a moderate anaſtomoſis with a branch of the vertebral artery, unleſs that ariſe from the undivided trunk of the carotid, afterwards aſcends a long way through the foſſa of Sylvius to the lateral part of the brain; and alſo ſends branches to the choroid plexus. All the branches of the carotid, contained within the ſkull, have a thin, ſolid, and more brittle ſubſtance than the other arteries of the body.

cccxviii. The vertebral artery commonly ariſes from the ſubclavian of the ſame ſide, (though the left has been ſometimes ſeen to ſpring from the trunk of the aorta,) in a deep ſituation, and without giving branches, it enters the foramen in the tranſverſe proceſs of the ſixth vertebra of the neck; after which, it aſcends with alternate flexures through the proceſſes of the other vertebræ of the neck; through each interval, it ſends off ſmall branches to the muſcles of the neck, and communicates with the lower thyroidal: with other branches, ſomewhat larger and poſterior, it accompanies each nerve to the pia mater of the ſpinal marrow; and by anterior branches, not ſo numerous, but larger, it communicates in the ſpinal marrow with its anterior artery. Laſtly, having become tranſverſe by a ſmall flexure at the ſecond vertebra, and by a large one round the proceſs of the firſt, having there given off two conſiderable branches to the muſcles of the neck, and during its paſſage through the foramen magnum, having ſent ſmall ones to the

dura mater of the foramen magnum and neighbouring cavity of the cerebellum, it finally enters the cavity of the ſkull through that foramen. There, while it aſcends along the medulla oblongata, the right trunk gradually approaching the left, unites with it at a very acute angle (a moſt uncommon circumſtance) into one artery, the baſilary, which being ſtretched under the pons Varolii, is ſuſpended in the pia mater. From the vertebral arteries, before they are conjoined, or from their common trunk juſt formed, arteries both going to the lower ſurface of the cerebellum, and entering deeply into the fourth ventricle and the internal ſubſtance of the cerebellum, ariſe. Theſe ſend off the ſpinal arteries. There are inſtances where theſe ariſe from the united trunk; or from the trunk in one ſide, and from a branch in the other. Then the baſilaris, beſides branches to the medulla oblongata and crura of the brain, ſends off other lower arteries of the cerebellum. Amongſt theſe branches alſo ariſes the artery, which accompanies the auditory nerve. Finally, the baſilaris, at the forepart of the pons, divides on each ſide into two branches. One of theſe goes to the upper part of the cerebellum, to the fourth ventricle, to the crura of the medulla of the cerebellum, the nates, teſtes, and pineal gland: in place of this, alſo, there are two trunks. The other, the profunda cerebri, is diſtributed to the poſterior lobe of the brain, the choroid plexus, the plexus lying on the pineal gland, that gland itſelf, the thalami, corpora ſtriata, fornix, and whole anterior ventricle.

cccxix. From the foregoing hiſtory of the arteries belonging to the brain, it appears, that in every pulſation a great quantity of blood is ſent to this organ, equal to a ſixth part or more of the whole blood in the human body, and conveyed by trunks which ariſe very near the heart, and from the convexity of the aorta. It is therefore not improbable,

probable, that the ſtrongeſt parts of the blood, and thoſe moſt retentive of motion, go to the head. Is not this evident from the effects of mercurials being almoſt confined to the head; from the ſudden action of inebriating ſpirits upon the head; from the ſpeedy ſtupor excited by camphor; from the face being oftner affected by heat and ſweat, than any other part of the body; and from the eruption of highly volatile miaſmata upon the face? The ſafe ſituation in which the arteries of the head aſcend, defends the large and important veſſels from injury. The frequent reciprocal inoſculations of the trunks going to the head, as well as of their branches, diminiſh the danger of obſtruction. Hence, when the carotids are tied, animals neither die, nor ſeem to be very uneaſy. The conſiderable flexures of the vertebral and carotid arteries, ſerve to moderate the impulſe of the blood coming to the brain, ſince a great part of the velocity, which it receives from the heart, is thus ſpent in changing the figure of the inflections. Some reputable authors have obſerved, that the arteries are ſomewhat larger at this place.

CCCXX. The hiſtory of the brain properly commences with its integuments. A part ſo tender and ſo neceſſary to life, is, in the firſt place, ſurrounded by an oſſeous ſphere compoſed of many pieces, which, therefore, admits of extenſion, while it effectually reſiſts external preſſure. To every part of the internal ſurface of this ſphere, a very ſtrong membrane adheres, compoſed of two plates ſufficiently diſtinct. It is firmly attached by an infinite number of ſmall veſſels, even penetrating to the exterior parts of the head, as by ſo many footſtalks; in a healthy perſon it is no where detached, but adheres ſomewhat leſs firmly to the very ſmooth bones, but with exceſſive ſtrength to the commiſſures of the bones of the ſkull, which, from their figure, are called ſutures. In young ſubjects, the

adhesion of the dura mater to the skull is so great, that the fibres to which it is connected are separated at the same time with it. In adults, many of the vessels being effaced, the dura mater becomes less inseparable : but yet it cannot be detached from the skull without some violence. Hence those bloody drops which appear on removing the cranium. Hence all that has been advanced concerning the motion of the dura mater is erroneous. As to the motion which has been remarked in wounds by some observers, it arose either from the pulsation of the arteries, in a place whence the resistance was removed, while the rest of the cranium afforded insuperable resistance to the action of the heart, or from the turgescence of the brain. The dura mater has neither irritability nor sensibility, and is destitute of nerves, though those going to other parts have been, by some, ascribed to this membrane.

cccxxi. It is the external lamina of the dura mater, which adheres to the bones, and serves them for a periosteum. It passes out of all the holes of the skull along the nerves and vessels, and coheres with the periosteum of the head, vertebræ, and, lastly, of the whole body; from which circumstance, the name of mater given to it by the barbarians, is derived. The internal plate of the dura mater is, in most parts, continuous with the former : but, in some, it recedes a little from it, as in the great sphenoidal wings ; at the sides of the sella equina, where a good deal of blood is poured betwixt them ; and upon the sella equina itself : having left the external lamina, which adheres firmly to the bones, it descends double to form the falx, which arises first from the multiform bone behind the crista galli, then from the crista, afterwards from the whole juncture of the two frontal and parietal bones, and, lastly, from the middle and back part of the occipital bone ; it becomes broader

broader as it proceeds backwards; it is interpoſed betwixt the hemiſpheres of the brain; and hangs over the corpus calloſum, at a greater diſtance in the forepart, but very near behind, where it alſo is extenuated to an edge. That there are ſhining fibres in this part, diſperſed towards the longitudinal ſinus, from its junction with the tentorium, in the ſhape of palm branches, is certain; but it does not therefore follow, that they have any muſcular motion: betwixt theſe fibres frequently there is no membrane, ſo that they form natural foramina. The falx is joined to the middle of the tentorium, and is continuous with it. In the ſame manner, but in a different ſituation, the ſame lamina forms the ſhort falx of the cerebellum, ſeparating its lobes, together with the ſtrong tentoria, which, ariſing from the cruciform protuberance of the occiput, are interpoſed tranſverſely betwixt the brain and cerebellum, and, at laſt, adhering to the petrous bones and anterior clinoid proceſſes, leave an aperture nearly oval for the medulla oblongata. Theſe productions of the dura mater, prevent any part of the brain from preſſing on the reſt, in any ſituation of the body; and, likewiſe, one lobe from compreſſing another, in concuſſions of the brain. Hence, in the ſwifteſt quadrupeds, where the danger from concuſſion is greater, the brain and cerebellum are divided by a bony partition.

cccxxii. Upon the external ſurface of the pia mater, not far from the ſinus of the falx, are placed glands, ſeated in the reticular texture of the dura mater, which partly are inclined towards the ſinus and its cavity, ſo that ſome of them are contiguous to the cavity of the ſinus, while others are ſo placed at the inſertion of the large veins into the pia mater, that, together with the former juſt mentioned, they make up a continued ſeries; theſe are ſometimes ſoft, oval, and white, ſometimes red, and hard, like warts. They have alſo been noticed in the

the tentorium cerebelli. But the vapour, which exhales from the ſurface of the pia mater, is not ſecreted by theſe glands: for every where, even where there are none of thoſe glands, as in the ventricles, a copious vapour tranſpires from the ultimate arteries, as is proved by injections of water or ſize, which exude from every part of the ſurface of the pia mater.

CCCXXIII. The next covering of the brain, much cloſer to it, and expreſſing its figure, as the former does that of the cavity of the ſkull, has been denominated, from its tenuity, arachnoid. Pellucid as water, very thin, and as far as its thinneſs permits, firm, it completely envelopes the brain, paſſing over its larger and ſmaller furrows, and incloſing the larger veſſels, ſo that they lie between the arachnoides and pia mater. It is not a lamina of the pia mater, from which it differs in ſituation, in being connected with it by cellular ſubſtance, and in the example of the ſpinal marrow, although it is reſolved into a cellular nature between the hemiſpheres of the brain.

CCCXXIV. The third covering of the brain, is the pia mater, or ſoft membrane of the brain. This immediately inveſts the whole ſurface of the brain and ſpinal marrow on all ſides, is tender, and compoſed of a vaſt number of ſmall veſſels joined together by cellular texture: but theſe veſſels it ſends into the brain in a regular order, like little roots. It deſcends into all the ſinuoſities, and inſinuates itſelf into the fiſſures of the brain, cerebellum, and ſpinal marrow, and is the bond by which the lobules of the brain are joined together, being poſſeſſed of conſiderable firmneſs in proportion to its tenuity. Being received into the cavities of the brain, it changes its fabric, and becomes ſoft and almoſt of a medullary conſiſtence, eſpecially when the ſubject is diſſected ſome time after death, although the veſſels ſtill point it out.

CCCXXV.

CCCXXV. The veins in the brain are not conſtructed as in other parts of the body. For neither have they any valves, nor do they accompany the arteries, nor have their trunks the common ſtructure which prevails in other veins. Therefore, from the innermoſt cavities of the brain, the veins which reſt upon the ridges of the ſtriated bodies, the veins of the choroid plexus, of the lucid ſeptum and of the anterior ventricles, are collected into trunks, which at laſt meet in one great vein, or often two, which, being accompanied with many ſmall arteries of the choroid plexus, deſcends backwards to the partition of the brain and cerebellum. In that place, it receives veins ariſing from the poſterior and lower part of the brain, and ſome of the cerebellum, and meets with a ſinus or vein, included in a reduplication of the inner lamina of the dura mater, and being changed into this ſinus, it generally deſcends into the leſs tranſverſe ſinus, moſt frequently of the left ſide, though ſometimes dividing, it ſends a branch to each ſide. This is called the fourth ſinus.

CCCXXVI. The ſuperior and ſuperficial veins of the brain are large, and ſpread in the windings with which the brain on all ſides abounds. Into thoſe veins, over the whole ſurface of the brain, are inſerted ſome veins of the dura mater ; while others of them enter by peculiar orifices into the falciform ſinus. Then the veins being gradually collected into trunks, proceed, the greateſt number of them forwards, a few either directly, or backwards, and theſe moſt eſpecially from the forepart, and inſert themſelves, with their terminations obliquely truncated, into the long falciform ſinus which is formed by the internal lamina of the dura mater, from the right and left ſide meeting together below in the upper edge of the falx. Therefore it is of a triangular figure, convex in its upper ſide. It begins with a ſlender origin at the foramen cæcum,

cæcum, which lies before the crifta galli; it afcends and follows the courfe of the falx; where that joins the tentorium, being generally inclined to the right, it takes the name of the right tranfverfe finus, and goes by a peculiar channel impreffed in the occipital and temporal bones, firft tranfverfely, then incurvated, to the foramen jugulare, where, becoming very large, it receives the inferior petrous and the occipital finufes, and empties itfelf into the jugular vein. But the left tranfverfe finus, refembling the former, and alfo leading to the jugular vein, is rather inferted into its right fide, than continued as its trunk. Into it the fourth finus (CCCXXV.) and the occipital one, ufually infert themfelves. But there are fome inftances of a reverfe arrangement, fo that the longitudinal finus terminates in the left tranfverfe finus; and then the right tranfverfe finus receives the fourth and the occipital one. At other times it is equally divided into two tranfverfe trunks; and fometimes a middle finus joins the tranfverfe ones. There even have been found two fimilar finufes parallel to each other.

CCCXXVII. Irregularly parallel with the lower and thicker margin of the falx, runs a flender and rounder finus, more refembling a vein; it receives veins from the falx itfelf, which alfo communicate with the upper finus; and from the adjacent hemifpheres of the brain, and from the corpus callofum. Where the falx joins with the forepart of the tentorium, it is inferted into the fourth finus.

CCCXXVIII. The lower veins of the brain, which lie next to the bafis of the fkull, are varioufly inferted. The anterior veins coming from the foffa Sylvii, collected into fome trunks, are inferted into the cavernous finus, or that triangular interval, between the external and internal plates of the dura mater, which is at the fide of the fella equina. Other

Other veins, from the pons itſelf, lead into the upper ſinus petroſus. Other poſterior veins, which come from the poſterior lobes of the brain, are inſerted in great numbers into the tranſverſe ſinuſes in the tentorium.

cccxxix. The upper veins of the cerebellum, meeting together in large trunks, partly terminate in the fourth ſinus, and partly in the tranſverſe ſinuſes. The lower veins, from the cerebellum and medulla oblongata, inſert themſelves into the upper ſinus petroſus; and ſome of theſe alſo into the tranſverſe ſinus very near the place where it goes out.

cccxxx. There are many ſinuſes, beſides thoſe now mentioned. The moſt anterior of them, which commonly has a circular appearance, ſurrounds the pituitary gland, and between the clinoid proceſſes, communicates with the cavernous ſinuſes; and between theſe proceſſes and the carotid, with the lower petrous ſinuſes, and laſtly, by the way of the ſixth pair, with the upper petrous ſinuſes behind the fifth nerve. There are ſome inſtances where this ſinus receives the ophthalmic vein; and ſometimes the tranſverſe, joining to the cavernous ſinus, ſupplies the place of this circular ſinus, or elſe coexiſts with it.

cccxxxi. The upper petrous ſinus runs backwards in a groove of the os petroſum. It ariſes from the anterior extremity of the ſulcus of the os petroſum, where it communicates with the cavernous ſinus; it receives veins of the dura mater which are inſerted into it, and ſometimes anterior veins of the brain itſelf, mentioned before (cccxxviii.) and is inſerted into the angle of the tranſverſe ſinus, where it begins to be bent, and ſometimes into the inferior petrous ſinus. Another vein, paſſing along the top of the os petroſum, is in like manner inſerted into the angle of the tranſverſe ſinus. The lower ſinus petroſus, which is ſhorter and

and larger, goes round the root of the bone of this name, and communicates with is fellow behind the clinoid proceſs; after twice communicating with the cavernous ſinus, and with the upper ſinus, under the nerve of the fifth pair, it is finally inſerted into the jugular foſſa; it alſo receives ſome veins of the dura mater from the region of the vertebræ. To the ſame outlet alſo, the poſterior occipital ſinus on each ſide leads. Theſe are pretty large, go round the margin of the foramen magnum, till, arriving at the falx of the cerebellum, (cccxxi.) they are ſooner or later inſerted, generally after being conjoined into the fourth ſinus, and with that into the left tranſverſe one, or immediately into this ſinus itſelf, or laſtly, by a divided extremity into each of the tranſverſe ſinuſes. It receives the lower and poſterior veins of the dura mater, and ſome from the vertebræ.

cccxxxii. The anterior occipital ſinus, irregular and multiform, partly tranſverſe, and partly deſcending to the great foramen, is united in various ways with the lower petrous ſinuſes; from whence branches either accompanying the nerves of the ninth pair, or paſſing through a peculiar foramen, communicate with the external vertebral vein; while other branches, going downwards, open into the venous circles of the ſpinal marrow. But the cavernous ſinus of the dura mater, (cccxxv.) which is ſurrounded with a good deal of cellular ſubſtance, beſides the ſinuſes (cccxxix. cccxxx.) and large veins already deſcribed, alſo receives the ophthalmic and principal vein of the dura mater; it likewiſe tranſmits peculiar veins, accompanying the firſt, and ſecond, and third branches of the fifth pair, the principal artery of the dura mater, (cccxvi.) and the internal carotid, (cccxvi.) and alſo through a foramen in the great wing, which is not conſtant; it ſends branches which inoſculate with veins on the outſide of the ſkull belonging to the jugulars, and eſpecially with the large pterygoid plexus of the naſal veins.

In

In the ſame manner, the veins of the pericranium paſs through foramina in the parietal bones into the longitudinal ſinus, the occipital veins through the maſtoid hole into the tranſverſe ſinus, and the external vertebral veins through the anterior canal of the occipital bone, into the foſſa jugularis; and others from the anterior occipital veins accompany the nerve of the ninth pair. Thus there are an infinite number of ways open to the blood, by which it may eſcape from the ſinuſes, wherein it is often collected in too great quantity, in various directions, according to the laxity or declivity of the part. Hence no violent ſymptoms follow upon tying a vein, however large, or even both the jugulars.

CCCXXXIII. The quantity of blood which goes to the brain, the great impulſe with which it is ſent into the carotid arteries, (CCCXIX.) the immunity of a part defended by bones from every kind of preſſure; the ſlow motion of the blood through the abdominal viſcera and lower extremities; the perpetual exerciſe of the brain and ſenſes, which determines an influx of blood to theſe parts, and other circumſtances, cauſe the head to be ſurpriſingly filled with blood, immediately on any increaſe of the circulation. Hence the redneſs of the face, the turgeſcence of the eyes, the ſparkling, the headach, the throbbing, the hæmorrhages from the noſe, which are ſo frequently produced by violent exerciſe. Therefore, it is evident, that, if the veins in the brain were thin and round, the imminent danger of rupture and apoplexy, even now frequent, could not poſſibly be avoided. On this account, to the veins which carry out the blood from the brain, nature has given another form more eaſily dilatable, becauſe it makes an unequal reſiſtance; and another texture, of great firmneſs, and more difficultly ruptured, eſpecially in the large ſinuſes, which perform the office of trunks; for the ſmaller ſinuſes are either rounder, half cylindrical, or

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of an irregular figure. Within, nature has furnifhed the finufes with crofs braces, formed of ftrong membrane, paffing from the right fide of the bottom of the finus to the left, which, in exceffive diftentions, ftrengthen the acute angle which is moft diftended, and fecure it from rupture. She has likewife, in thefe veins, provided numberlefs inofculations, both mutually amongft themfelves, and with the external veffels of the head, and with thofe of the fpinal marrow, that they may, with greater facility, difcharge their fuperabundant blood, (CCCXXXII.)

CCCXXXIV. Is arterial blood alfo poured into the finufes of the brain? Do they pulfate, by being excited by that blood? It is allowed, that they have no pulfation; becaufe the dura mater every way adheres to the fkull, and moft firmly in the regions of the finufes. They certainly receive liquors injected by the arteries. Whether are thefe exhaled through the fmall veffels, or do they, in the firft place, circulate through the veins? The latter opinion is much more probable.

CCCXXXV. All the blood of the brain is finally conveyed into the jugular veins, which are very dilatable, and for that reafon protected by valves, againft the regurgitation of blood from the auricle, and furrounded with a great quantity of cellular fubftance. For the blood, which comes from the head to the vertebral veins, is very inconfiderable. The jugulars, fo directly correfpond with each of the principal branches of the vena cava fuperior, that they bring back the blood to the heart in the fhorteft way, and that the right one proceeds in a ftraight line from the right auricle. They feparate nearly as the arteries, into a facial and cerebral branch.

CCCXXXVI. The external jugular is a cutaneous vein of the neck, which gives off the temporal one: it is united by a broad anaftomofis with the internal jugular at the bafis of the lower jaw; and fends a

branch through the os mamillare into the tranſverſe ſinus. The internal vertebral empties itſelf through the tranſverſe proceſſes of the neck into the tranſverſe ſinus, when the canal belonging to it is open.

cccxxxvii. The ſinuſes of the ſpinal marrow, which are two in number, and lateral, run along its whole length, are joined at each vertebra by a ſemicircular arch, and are finally united with the jugular and occipital ſinuſes: they ſend branches, however, to the ſpinal marrow, communicating with the anterior and poſterior ſpinal veins.

cccxxxviii. In conſequence of the innumerable anaſtomoſes of the veins, the blood returns with the greateſt facility from the head, of which the repletion is attended with much danger. During inſpiration, the brain is alſo more eaſily evacuated, and ſubſides when the ſkull is opened; during exſpiration, on the contrary, it ſwells. Hence, blowing the noſe, ſneezing, and coughing, are dangerous to thoſe whoſe brain is turgid with retained blood.

cccxxxix. Have lymphatic veſſels been ſeen with certainty in the brain? They have been deſcribed in the large choroidal plexus, amongſt the fibres of the olfactory nerve, and in the pia mater. For my own part, I have never ſeen them, and it is probable that there are none, ſince there are no conglobate glands in the brain, which are always found near theſe veſſels. As for the various accounts which are given of the pituitary gland, of the infundibulum, and of the ducts which lead from thence into the veins of the head, abſorbing water from the ventricles, they are not ſupported by any anatomical demonſtration: which makes it probable, that the vapour, which is ſecreted into the ventricles of a healthy perſon, is, in like proportion, abſorbed again by the inhaling veins; and that if there be any exceſs, it deſcends through the bottom of the ventricles to the baſis of the ſkull, and into the

the loofe cavity of the fpinal marrow. That this is the cafe, appears from palfies, which enfue after apoplexies ; and from the watery tumours in the lower part of the fpinal marrow, in hydrocephalic patients.

CCCXL. It now remains for us to fpeak of the encephalon itfelf. There are feveral parts included under this general denomination. By the brain, properly fo called, we underftand the upper part of that vifcus, which is contained in the fkull, and which alone occupies its anterior portion ; but behind, it lies above another part, called the cerebellum, which is fituated in the pofterior and lower cavity of the occipital bone, under the tentorium. Its lower, middle, and white portion, lying under the brain, and before the cerebellum, is in part called the pons, and in part the medulla oblongata.

CCCXLI. The figure of the brain refembles that of half an egg, which is deeply divided longitudinally, not through the whole, but through more than the half of its length, into hemifpheres, refembling the quarters of an egg. Both the upper and lower furfaces in man, are full of convolutions, which, with alternate round angles, pretty deeply divide the brain into undulated lobes. But the largeft is, that which afcends on both fides outwards from the fides of the fella turcica, and divides the hemifphere into two lobes. Upon the furface of thefe lobes, lies the cortex, which is extremely foft, and of an afh colour, tinged with yellow or red. It is the moft tender of all the parts in the human body. The internal parts are occupied by the medulla, which is almoft white, but redder in the fœtus ; perforated by very numerous, rectilineal and fimple arteries, more folid and more capable of fuftaining its figure, notwithftanding it is very foft, and in greater quantity than the cortex. The greater pofterior branch of the carotid artery (CCCXVII.) divides each hemifphere of the brain into a fmaller anterior lobe, and a larger pofterior lobe.

CCCXLII.

CCCXLII. The fabric of the cortex was long a ſubject of controverſy; but it is now ſufficiently evident, from anatomical injections, that much the greater part of it conſiſts of veſſels, which ariſe in every part from the branches of the pia mater, like footſtalks, enter into the cortical ſubſtance, and convey a fluid thinner than blood; and ſometimes, in diſeaſes from ſtrangulation, and in animals, eſpecially in birds, they receive even the true blood. The remaining part of the cortex which is not filled by any injection, is probably either an aſſemblage of veins, or of yet more tender veſſels; for no diſſimilarity, which would lead us to conjecture one part of it to be tubular, and the other part ſolid, is apparent in the cortex, in its healthy ſtate. Beſides, of the apparently uniform cortex, a greater portion becomes vaſcular, the greater the induſtry which has been employed in filling the veſſels, and the greater the tenuity of the injection. The idea of its being glandular, has been diſcarded by univerſal conſent; nor indeed was there ever any opinion received with leſs probability than this.

CCCXLIII. In order to underſtand the nature of the medulla, we are to conſider the internal ſtructure of the brain, compared with the brains of brute animals and fiſh. That part of the brain which lies immediately under the external convolutions, is of a white colour, and becomes gradually broader and more abundant; ſo that at length, it compoſes the whole oval ſection of the brain, except only cortical covolutions on its ſurface. In this part, the two hemiſpheres of the brain, which I before obſerved were not entirely divided, are united by a central portion of medulla. That part of the medulla which lies under the falciform proceſs, but at ſome diſtance from it, is called the corpus calloſum; in the upper ſurface of which run two parallel white ſtripes, formed by the pulſation of the arteries, diverging forwards, and terminated at the anterior

anterior commiſſure, and in like manner divided backwards. The anterior extremity of the corpus calloſum, is loſt in the ſubſtance of the crura cerebri, coming from the anterior lobes of the brain: the poſterior extremity, which is broader, with its ſhorter termination bent in the ſhape of a talon, penetrates inwards, and deſcends with another portion into the inferior horn of the ventricle; and with its longer termination is continued into the hippocampus. Moreover, the whole ſurface of this ſubſtance is ſtreaked with tranſverſe fibres, which are continued, but extenuated, into the adjacent medulla of the brain. Even its interior ſubſtance is of a ſtriated nature, and its lower ſurface has its raphe and tranſverſe fibres.

cccxliv. What follows is more difficult to be underſtood; for the brain is not ſolid, but from the bottom of its medullary portion, which is incumbent upon the multiform bone, where the greater crus of the brain paſſes out from it, a cavity commences, covered only with the pia mater, which gradually aſcends backwards, and then turning, continues its courſe forwards and upwards. Then it divides itſelf near the poſterior extremity of the corpus calloſum; and with its ſhorter poſterior portion it ends in the poſterior lobe of the brain, with its extremity directed inwards, and filled with the talon mentioned above; but its anterior portion is extended along the ſide of the corpus calloſum, parallel to the horizon, and with a horn increaſing in breadth outwards, it terminates in the anterior lobe of the brain. The cavity thus formed, of which there is one in each hemiſphere of the brain, and which do not communicate, is called the ventriculus anterior or tricornis. It is naturally filled with vapour, which is frequently condenſed into water or jelly.

cccxlv. This cavity has no vacuity, for the upper and lower portions of the brain mutually touch each other.

other. Below, its floor is variouſly figured. Anteriorly, it conſiſts of a horn, having in its lower part an eminence, which is ſlightly convex, long, diverges backwards, is covered with an extremely vaſcular membrane, and is outwardly cinereous. They are called the corpora ſtriata; becauſe inwardly they exhibit, intermixed with much cortical ſubſtance, alternate white oval ſtreaks, parallel to one another, and longer behind, beſides leſſer ſpots and points, as if of medullary ſubſtance. More inwardly and poſteriorly, two other ſimilar eminences, more of an egg like ſhape, towards the third ventricle and other parts in a great meaſure cinereous on the outſide, and obſcurely ſtriated, incline towards each other, ſo that they frequently cohere on the upper part, by the intermixture of their cortical ſubſtance: theſe, going inwards and deſcending through the horn of each anterior ventricle to the baſis of the ſkull, generate the optic nerves, of which they are called the thalami. Between the corpora ſtriata and thalami, there is an intermediate, parallel, and white band of medullary ſubſtance, which is called the centrum ſemicirculare geminum, produced from the anterior commiſſure, and frequently from the crura of the fornix; but eſpecially from the medulla of the brain itſelf, before the thalami. This commiſſure, which is broad and ſtrong, joins together the anterior part of the brain before the thalami. The centrum geminum, which is broadeſt behind, ariſes with many fibres from the junction of the pes hippocampi with the medulla of the brain. The corpora ſtriata, with the thalami, conſtitute the medullary crura of the brain; which, in the baſis of the cerebrum, paſs over the medulla of the cerebellum, and are joined together at the anterior extremity of the bridge, to be deſcribed hereafter. Where they approach neareſt to one another, each ſends out an hemiſpherical eminence, called mamillary. The fibres of the medulla of the brain itſelf,

interwoven with the medulla of the cerebellum, defcend into the medulla oblongata; and, being then collected into a bundle, they go to the corpora pyramidalia.

CCCXLVI. The corpus callofum projects in the middle over the common axis of thofe ventricles. Behind, it refts contiguoufly upon the fornix. Before, two fimilar medullary partitions, which are called the feptum lucidum, triangular, united below, with their vertex inclined backwards, and including an anonymous central cavity, defcend from this body along the corpora ftriata, even to the union of the thalami. This feptum below is continued to the fornix, which is a ceiling fupported on four pillars, having its anterior origin from the medulla of the brain, and fometimes from the mamillary protuberances, and the commiffure which we have mentioned; and behind that, particularly under the thalami, often both from the centrum geminum and curved line of the thalami. This fornix is incumbent upon the interval between the corpora ftriata, and upon the interval between the thalami; and degenerates partly into a broad thin fimbria, the pes hippocampi, where it is divided into toes; and partly into other tubercles, which are continuous both with the fornix and corpus callofum, but more evidently continued from the latter, as larger, and are femi-cylindrical, having the fimbria attached to them. Thefe defcend into the lower anterior horns of the ventricles; and at laft terminate in an arch, convex outwards, and commonly divided by ten furrows, imprinted on it by the convolutions of the brain, and in a four toed hoof, whence the name of hippocampus, which is externally covered by an exceedingly thin medullary lamina, but internally confifts of cortical fubftance. At the beginning of the divifion of the pes hippocampi, the tænia ends in two white ftriæ, a long and a fhort one, inferted into this foot and into the brain, or in one inferted

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into the moſt internal unguis. A like protuberance, continuous with the corpus calloſum, enters into the poſterior horn of the ventricle, crooked inwards at its extremity, like the ſpur of a bird, the poſterior part of the deſcending horn of the ventricle being occupied by a column continuous with it. Between the diverging poſterior crura of the fornix, the medullary portion, which is behind the middle plexus of the ventricles, and marked generally with tranſverſe and palmated ſtreaks, is called the pſalterium.

CCCXLVII. In the anterior and lower part of the ventricles, on each ſide, begins the choroid plexus, included in the pia mater only, lying naked in the reſt of the cavity of the ſkull, made up of a great many ſmall arteries (CCCXVII. CCCXVIII.) and veins originating from the large trunk, (CCCXXV.) all which numerous veſſels, joined together by the pia mater, reſemble a curtain variouſly folded. It is often, but not always, intermixed with many pellucid glands of a round figure, reſembling hydatids. It aſcends from the baſis of the brain, through the deſcending horn of the ventricle, and becomes dilated as it proceeds upwards; but afterwards becoming narrower, it goes along the optic thalamus, to the poſterior extremity of the ſeptum lucidum. When theſe plexuſes have reached the anterior extremity of the thalami, they cohere, and are continued with a remarkable vaſcular plexus, which gradually deſcends along the roof of the third ventricle as far as the pineal gland, and is continued into the pia mater of the poſterior lobes of the brain. From this proceeds the internal warmth of the brain, and it undoubtedly exhales and inhales. The choroid plexuſes are very broad where the anterior ventricles begin to deſcend; contracting gradually downwards, they project in the inferior anterior end of the ventricle, covered only by the pia mater.

CCCXLVIII. Between the thalami, applied to each other almoſt with a plain ſurface, there is a natural

 fiſſure,

fiſſure, which is terminated by the crura of the brain meeting together in the baſis of the ſkull: this is called the third ventricle. It leads by a perpendicular funnel, forwards into a cortical column; it is hollow in brutes, leſs evidently tubular in man, and connected to the pituitary gland.

CCCXLIX. This gland, flattened on both ſides, ſimple, of uncertain ſtructure; in the anterior larger part, almoſt round, and of a reddiſh colour; in the poſterior part leſs, cinereous, tranſverſely broad; covered with the pia mater of the brain; lies upon a proper depreſſion of the ſella turcica, and ſeems to be a kind of appendix to the brain.

CCCL. Backwards, the thalami, are conjoined in the bottom of the ventricle, by a central medullary faſcia, or poſterior commiſſure, and by a ſmaller tranſverſe chord; from which, on each ſide, an arched white band goes out in the upper part, which loſes itſelf in the centrum geminum, and in the anterior commiſſure, and ſometimes in the crus of the fornix. On the fore and upper part, the thalami have a protuberance, which is formed by the triangular fornix ſituated between the two thalami.

CCCLI. This eminence ſeparates the upper triangular cavity of the third ventricle, filled up with the fornix, from the inferior calamus ſcriptorius, ſo that the cavity is continued both to the anterior and poſterior extremity of the third ventricle, from the top to the bottom. But the anterior commiſſure is alſo a medullary band which unites the thalami before the anterior crura of the fornix.

CCCLII. For a poſterior, tranſverſe, figured eminence is applied to the thalami, which conjoins the medulla of the right and left poſterior lobes of the brain. It is marked behind by four oval eminences, which are outwardly ſmaller, called the nates and teſtes, and which conſiſt externally of ſome medulla, and internally of cortical ſubſtance.

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The ſuperior ones in man are the largeſt, and are called the nates. Upon theſe is ſeated a cortical gland, ovally conical, ſupplied with many veſſels, into which the choroid plexus degenerates: this is the celebrated pineal gland ſo frequently diſeaſed, which is joined to the brain by ſmall footſtalks ſent into the linea alba through the thalami in their paſſage forwards. Between this eminence, marked with theſe four protuberances, and the crura of the medulla oblongata, a canal reſembling an aqueduct, and manifeſtly open, paſſes from the third to the fourth ventricle.

CCCLIII. The whole medulla of the brain below, is collected together in its baſis, into two very thick compreſſed columns, having their ſurface longitudinally marked with lines, and conſiſting externally of medulla with ſome cortical ſubſtance internally. Theſe are the crura of the brain. Theſe, meeting together backwards, are covered by the ſubjacent crura of the cerebellum, and are inſerted by apparent ſtrata of fibres into the pyramidal bodies of the medulla oblongata; and with other deeper tranſverſe fibres, which ſeparate the inner fibres that come from the cerebellum from the preceding, conſtitute, together with the medulla cerebelli, the beginning of the medulla oblongata.

CCCLIV. The cerebellum, as it is leſs, ſo it is more ſimple than the brain. It has two lobes, but no where deeply parted, united above and below by a central ring of the ſame fabric with itſelf, called the vermis, at the ſide of which there is a broad ſmooth eminence of the ſame nature with the cerebellum. This part of the encephalon contains a great deal of the cortical, and little of the medullary ſubſtance. And here, likewiſe, the cortex is placed in the circumference, but marked with furrows, which are moſtly parallel, ſo as to form circular arches. Thus the lobules are defin-

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ed. but not deeply, each of which contains its medulla, and by the gradual union of many of these medullary branches into one trunk, an arbuscular appearance is produced. This medulla, collected together into the large crura of the cerebellum, and internally marked with serrated and intricate cortical lines, has a threefold termination. One part ascends towards the basis of the nates, where it joins the medulla of the brain under the testes; and the right is also joined to the left by a transverse medullary band behind the nates. From this, some distinct fibres ascend outwards, and join themselves to the transverse ones of the bridge. Between these first processes of the cerebellum, is stretched a medullary lamina, behind the fourth ventricle, sending forth fibres beyond the process. The second portion descends into the spinal marrow, and terminates in peculiar studded protuberances, having other cortical protuberances adjacent, both of which are anonymous. The third portion, which is larger, and situated in the middle, going transversely downwards, passes under the crura of the brain, which it embraces; and being twice alternated with their medullary fibres, (CCCLII.) by its own transverse fibres, it is in a great measure blended with them.

CCCLV. Thus, from the crura of the brain descending over those of the cerebellum, and from the medulla of the cerebellum transversely surrounding that of the cerebrum, there is produced, in the first place, the pons, which is almost oval, but more flattened on both sides, depressed in the middle, and every where marked with transverse fibres. Then, continuous with the pons, the medulla oblongata is formed, which is internally variegated and streaked with some cortical substance, is of a conical shape, and descends directly to the great foramen. This medulla has two pairs of tubercles before the pons; the outermost of the figure of

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an olive, and the innermoſt of a pyramidal ſhape, diminiſhing conically downwards: theſe are divided in the middle by a furrow, into which the pia mater enters. But betwixt this medulla and the vermiform proceſs of the cerebellum, is formed a cavity, limited by the four leſſer proceſſes, which aſcend and deſcend; at firſt it is narrower, but above the tubercles (CCCLIV.) it grows broader, and is of a rhomboidal figure: it is called the fourth ventricle, and is ſhut behind by the valvula magna, or medullary velum, which unites the proceſſes going from the cerebellum to the nates, and the vermis, with the tranſverſe band lying under the teſtes, and ſhuts the ventricle behind, (CCCLIV.) This ventricle has a moderate furrow, bounded on each ſide by tumid edges, inſcribed on the medulla oblongata, and correſponding to a canal which is covered by the nates and teſtes, and is called the aqueduct, (CCCXLVIII.) In this laſt ventricle, as in the foregoing, there is a plexus choroides, only leſs, and a ſulcus called calamus. Each of theſe ſulci is continued down along the medulla ſpinalis, the anterior moſt evidently, the poſterior leſs ſo. In the former, tranſverſe fibres are detached from the right to the left ſide, both in the medulla oblongata and ſpinalis. But two or three of the tranſverſe ſtreaks of the fourth ventricle, terminating in the ſoft nerve, ariſe from the eminences incloſing the ſulcus; others go to the eighth pair, and others of the ſame kind aſcend to the crus of the cerebellum.

CCCLVI. All the medulla of the brain and cerebellum paſſes out from the ſkull, through different openings, to the places for which it is deſtined. The ſmaller bundles of this medulla we call nerves; but the larger, which is a continuation of the oblongata, we call the medulla ſpinalis. The nerves are medullary faſciculi, very ſoft in their origin, and compoſed of chords of fibres meeting from the brain,

brain, even there in ſome examples, diſtinct, ſtraight and parallel in the nerve. Theſe chords, after having proceeded ſome way, and being covered with the pia mater, which is ſomewhat red and firm, are united into a more conſtant faſcia; and then, conjoined with others of the ſame kind by cellular membrane, divided, and contiguous, go on to their proper opening in the dura mater, and run along its canals and intervals, till they meet with an opening in the ſkull, out of which they paſs through a funnel of the dura mater. The nerve, having arrived without the ſkull, is commonly ſurrounded by the dura mater, and becomes ſolid and firm. This is the caſe in the optic nerve, in the fifth pair, and in others; but in ſome again there does not appear to be any dura mater ſurrounding the nerve, as in the olfactory nerves, in the ſoft portion of the auditory nerve, and the intercoſtal. The nerves, now naked and leſs defended, amongſt the muſcles, are compoſed of chords, each of which has its medulla, and its ſheath of pia mater. The ultimate chords of this kind unite into other larger chords, ſurrounded by much cellular ſubſtance, through which run many ſmall arteries and veins; and ſometimes fat itſelf is depoſited. But the general covering, common to the whole nervous bundle, is formed by ſome indurated cellular ſubſtance, often reſembling a true membrane, which envelopes them all, and combines them into one nerve.

CCCLVII. The whole of the nerves of the head ariſe from the lower part of the medulla of the brain or cerebellum. The olfactory nerve ariſes by a lateral fibre from the interval betwixt the anterior lobes of the brain, and by a direct fibre from the medulla of the anterior lobe itſelf. A great part of the optic nerve ſprings from the thalami, (CCCXLV.) but ſome part likewiſe from the crus of the brain, while the nerves decuſſate it. The third pair ariſes from the bottom of the crus of the medulla of the brain,

brain, behind the mamillary proceſſes. The fourth, whether ſimple or bifid, proceeds from the ſide of the proceſs of the cerebellum to the teſtes. The fifth ariſes plainly from the peduncles of the cerebellum. The ſixth from the bottom of the pons, from the deep ſulcus (CCCLIV.) between it and the medulla oblongata. The ſeventh ariſes with one portion, which is ſofter, poſterior and larger, from the medulla oblongata, and by two tranſverſe ſtriæ, from the fourth ventricle itſelf; and with another harder portion, from that part of the crus of the cerebellum next the pons. The eighth from the interval between the corpora olivaria and pyramidalia, out of a furrow of the medulla oblongata; and, according to the obſervation of other eminent anatomiſts, from the fourth ventricle itſelf. The ninth ariſes from the corpora olivaria and pyramidalia. The tenth is a nerve of the neck, as appears from its double root, its conjunction with the upper and lower adjacent nerves, and its place of origin. Therefore, no nerves ariſe properly from the cerebellum, unleſs the fifth and fourth; for the anterior nerves, the olfactory, optic, and third pair, come from the brain only; and all the reſt from thoſe parts where the medulla, both of the brain and cerebellum, are conjoined.

CCCLVIII. The ſpinal marrow is a very ſoft medullary rope, which deſcends from the medulla oblongata, as low as the ſecond vertebra of the loins. In the neck it is flat before and behind, and gibbous at the ſides; in the back it is almoſt quadrangular. It is largeſt where it goes out from the head; from thence it becomes ſmaller in the top of the neck, then larger at its lower part; again it is ſmaller throughout almoſt the whole back, but thicker at bottom; and laſtly, it ends in tubercles, one conical, another oval. Like the brain, it is inveſted with its own pia mater, which enters deeply into its anterior fiſſure, and almoſt divides the me-

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dulla into two. Within it has ſome obſcure cortical ſubſtance ; its anterior artery ariſes in the ſkull, from the branches of the vertebrals ; it is retrograde, deſcending through the whole length of the pia mater, perpetually making alternate ſinuous flexures, forming inoſculations about many, but not all of the nerves, with branches of the vertebral, intercoſtal, lumbar, and ſacral arteries ; till at laſt, covered with a peculiar coat from the pia mater, it goes out at the coccyx and diſappears. Two poſterior arteries, ſimilar, but ſmaller, ariſe from the lower arteries of the cerebellum : theſe are more ſerpentine, and have frequent mutual inoſculations. The ſpinal veins accompany the arteries in their deſcent from the brain itſelf, and ſend out branches in like manner, accompanying the nerves into as many circular ſinuſes, ſituated in the dura mater, as there are vertebræ, all of which ſo communicate one with another, that each communicates with thoſe above and below it, by a ſtraight duct, in each direction, and, by a branch ſent outwards, unites with the vertebral, intercoſtal, lumbar, and ſacral veins. The uppermoſt of theſe ſinuſes inoſculates with the anterior occipital ſinuſes, (CCCLII.)

CCCLIX. But the ſpinal marrow is ſurrounded by another covering, looſely and at ſome diſtance, which is not vaſcular, but pellucid like water, tolerably firm and continued from the brain. It is called arachnoid, is longer than the pia mater, being extended to the bottom of the os ſacrum, and there it alone includes the bundle of contiguous nerves. But in what manner it accompanies the nerves in their paſſage out, has not been hitherto deſcribed. Between that membrane and the dura mater, there is a vapour, which is frequently condenſed into a reddiſh water, and produces a true dropſy.

CCCLX. Laſtly, the dura mater of the ſpinal marrow is continuous with that of the brain, ſurrounds the

the arachnoides, in like manner defcends to the bottom of the os facrum, larger at its beginning, at the bottom of the neck, and at the loins, but flenderer in the back, and at laft terminates in a flender cone, attached by many ligaments to the periofteum of the os facrum. As the nerves pafs through this membrane, it gives them an external covering, which directly enlarges with them into a ganglion, or hard, oval, reddifh knot. To this dura mater in the intervals between all the nerves, a denticulated ligament internally adheres, which arifes from the fkull near the paffage of the ninth pair of nerves, and connects the arachnoid to the dura mater by triangular productions, in each of the intervals, between the anterior and pofterior bundles of the nerves down to the bottom, and twelfth vertebra of the back. Externally, the dura mater is furrounded by fome lubricating fatty matter, and then by the internal covering of the vertebræ, which are themfelves fo conftructed into a canal, that the fpinal marrow is not compreffed by it in any of its flexions.

CCCLXI. The fibres of the fpinal marrow appear diftinct in dropfical fubjects, and in brute animals. Thefe arife from the whole anterior and pofterior furfaces of the fpinal marrow; and commonly the anterior chords included in the pia mater, converge like rays into a larger fafciculus; to which a fimilar fafciculus of the pofterior filaments accedes, forming one nerve, which, paffing out through a hole of the dura mater, between every two vertebræ, produces a nerve. The vertebral nerves are about 30 in number. In the neck, numerous radiated nervous fibres compofe one large and almoft tranfverfe nerve. In the back, they defcend, in general, fmaller; but fo that the lower and larger ones are commonly contiguous to one another. The large and long lumbar ones join to form the cauda equina. The loweft nerves of the os facrum are very fmall, the

the uppermoſt ones large. Many of the dorſal nerves, together with the lumbar and ſacral ones, covered with their proper pia mater, accompanied by their arteries, and incloſed in the arachnoid membrane, conſtitute that chord which is called the cauda equina.

CCCLXII. Thoſe nerves are diſtributed to all parts of the body in a very complicated manner, which does not admit of a deſcription in this place. But the following particulars cannot be paſſed over. All the ſpinal nerves, except one or two in the neck, after paſſing out of the vertebræ, have both an anterior and poſterior trunk. The former is ſent to the muſcles only. The latter forms a nervous root, which joining with its fellows, and with a ſmall acceſſory branch, which comes through the pterygoid canal, from the ſixth nerve of the brain, and the ſecond branch of the fifth, forms one of the principal nerves of the human body; which, communicating with almoſt all the other nerves of the whole ſyſtem, ſends out nervous branches to the heart, and to all the viſcera of the abdomen. It has as many ganglia as it has roots from the ſpinal marrow, unleſs when ſeveral of them join into one ganglion. It communicates variouſly with the crural, brachial, and diaphragmatic nerves, alſo with the par vagum and ninth pair. Another principal nerve is the eighth or par vagum, ariſing from the brain, and joining itſelf to the intercoſtal in the bottom of the neck, in the thorax, and in the abdomen; this paſſes out of the ſkull in three chords, of which the larger ſends branches to the larynx, throat, the cardiac plexuſes themſelves, (XCIX.) lungs, œſophagus, ſtomach, and liver. The third of theſe is the phrenic nerve, ariſing from moſt of the lower nerves of the neck, and having received an augmentation from the brachial nerves, and ſometimes from the root of the ninth, it deſcends along the pericardium, and inſerts itſelf into the upper ſurface of the diaphragm; below, it is ſupplied from the

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great plexus of the intercoſtal nerve. Laſtly, the acceſſory nerve, ariſing by many ſmall roots from the ſix or ſeven uppermoſt poſterior cervical nerves, and from the medulla oblongata, returning into the ſkull, joins the eighth pair and ſeems to produce ſome ſympathy betwixt that important nerve and the ſpinal marrow. Finally, the nerves of the limbs originate from plexuſes, and are on account of their length, harder and larger, than the nerves which go to the viſcera: thoſe which go to the hand, ariſe from the four lower nerves of the neck, and firſt and ſecond of the back; thoſe of the lower extremities from the nerves of the loins and os ſacrum.

CCCLXIV. The nerves divide into branches like the blood-veſſels, but in acute, and often manifeſtly retrograde, angles, growing gradually ſofter and ſmaller, though ſometimes they become thicker, as they recede from the brain; at length, with their ultimate extremities, which are ſeldom viſible, ſeem to terminate in a pulp, by depoſiting the firm integuments with which they were covered, after the manner which we obſerve in the optic nerve. But the rectilineal courſe of the fibres, continued from the brain itſelf, is ſuch, that they are never divided in any ramification, but only recede from each other, where they had been connected by cellular ſubſtance. This appears from diſorders, confined to ſome particular parts, not extended to the whole, produced by affections of the brain; as a loſs of the voice, deafneſs, dumbneſs, and palſies of particular muſcles. They are connected by cellular ſubſtance to the adjacent parts, have hardly any elaſticity; do not contract on being divided, but only expel their medulla by the contraction of their integuments. In whatever way they are irritated, they do not contract, nor are they rendered ſhorter during the motion of the muſcles which they excite. A great many nerves are ſent into the muſcles;

cles; many to the ſkin; fewer to the viſcera; very few to the lungs; and none to the dura or pia mater, arachnoides, tendons, capſules, ligaments, and laſtly the whole ſecondary membranes. Like the veſſels, they make frequent anaſtomoſes with each other, or out of one trunk they are divided into many branches: and it is principally in the concourſe of branches, ariſing from different trunks, that the ganglia are found. Theſe are hard nervous tumors, for the moſt part vaſcular, and included in a firm membrane, of which the uſe and ſtructure are uncertain, and in which the ſtraight courſe of the nervous fibres is interrupted. They are not found in the nerves of the ſenſes, or in the eighth pair; or in the phrenic nerves; or in the nerves of the extremities; but are peculiar to the ſpinal nerves, to the intercoſtal, which is in fact a ſpinal nerve, and to the fifth pair.

CCCLXV. Theſe are nearly what we have learned from anatomy concerning the brain and nerves; the phyſiological uſes of theſe parts remain to be inveſtigated. Every nerve which is irritated, by whatever cauſe, produces an acute ſenſe of pain. Senſation is a change of the mind, produced by a change of the body. It is the medullary part of the nerve which feels. If a nerve be appropriated to any peculiar ſenſe, that ſenſe periſhes when the nerve is compreſſed or divided; and the ſenſibility of the whole body is deſtroyed, when the brain is compreſſed; or of thoſe parts whoſe nerves originate below the ſeat of preſſure, if you compreſs the ſpinal marrow. If certain parts of the brain, from which particular nerves ariſe, be compreſſed, then theſe ſenſes only are loſt, as the ſight or hearing. Thoſe parts of the body which receive nerves, poſſeſs ſenſibility moſt acutely, when they receive many, as the eyes and penis; obtuſely, when they receive few nerves, as the viſcera; and thoſe which have no nerves, as the dura mater, tendons, ligaments,

ments, ſecundines, the broad bones, and cartilages, have no ſenſation.

CCCLXVI. It is extremely probable, that all ſenſation ariſes from the impreſſion of a ſenſible object on ſome nerve of the human body; and that the ſame being tranſmitted to the brain along that nerve, is at laſt repreſented to the mind, after it has reached the brain. It therefore ſeems to be falſe, that the mind perceives immediately by means of the ſenſoria and branches of the nerves. For this opinion is refuted, by the pains felt after amputation, by the entire ceſſation of pain when a nerve is compreſſed, and by the diſeaſes of the ſenſes from injuries of the brain. That the effect of the ſenſes is preſerved in the brain, is evident from the loſs of memory which ſucceeds compreſſions or injuries of the brain; alſo from the delirium which happens in ſome diſeaſes, and the ſtupor and ſleepineſs which happen in others. We have already obſerved, that the dura mater has no ſenſation.

CCCLXVII. Another office of the nerves is to excite the muſcles into powerful action. When a nerve is irritated, the muſcle to which it goes is immediately convulſed; or the muſcles, if it ſend branches to ſeveral. This happens during the life of the animal, and a little after its death while all the parts are ſtill moiſt. By great irritation, other muſcles are thrown into convulſions, and even the whole body. Nor is it neceſſary that the nerve ſhould be entire; for even when it is cut, on being irritated, it will excite ſimilar motions in the muſcles. On the other hand, when a nerve is compreſſed or tied, a palſy follows; for the muſcles which have their nerves from that one, lie unmoved, when they are commanded by the will to act. They again recover their mobility, when the compreſſion is removed, provided the nerve has received no injury.

CCCLXVIII.

CCCLXVIII. When the medulla of the brain is deeply wounded or irritated in its crura, dreadful convulſions enſue throughout the whole body; the difference of the part irritated produces no exception; nor does the brain, cerebellum, or corpus calloſum, enjoy any perogative in this reſpect. The ſame conſequences follow, if the ſpinal marrow be irritated. But if the encephalon itſelf be compreſſed, in any part whatever, there enſues a loſs of ſenſe and motion in ſome part of the body, which appears to be exactly that which has its nerves from the part compreſſed, according to obſervations of injuries of particular portions of the brain, in which the origin of the nerves being compreſſed, the voice is loſt; or the motion of one arm or leg, or of one ſide of the pharynx. In injuries of the ſpinal marrow, it is ſtill more evident, that thoſe parts which receive their nerves from the place injured, are convulſed if that be irritated, or rendered paralytic if it be compreſſed. But when any more conſiderable portion of the brain is compreſſed, either from blood, water, ſcirrhus, an impacted bone, or other mechanical cauſe, the greateſt part, or the whole of the body, loſes its power of motion; the voluntary organs, if the leſion be in a leſs degree, and all of them when it is greater; all theſe diſorders ceaſe upon removing the compreſſing cauſe. Laſtly, if the ſpinal marrow in the neck be injured, death quickly enſues; becauſe, from that part the nerves of the heart (XCIX.) principally ariſe.

CCCLXIX. Theſe things being conſidered, there ſeems to be no doubt, that all motion in the human body, proceeds in a great meaſure from the brain, and its annexed cerebellum and ſpinal marrow; and that it is thence conveyed through the nerves, to all the muſcles and parts of the body. Beſides, the cauſe of motion cannot reſide in the parts themſelves, ſince it would then remain after the brain is deſtroyed, and

and would not be increafed by irritating the brain, or weakened by compreffing it.

CCCLXX. Is there in the brain any principal part, which is the origin of all motion, the end of all fenfation, and where the foul has its feat? Is this proved by the frequent obfervation of the integrity of the fenfes, and power of motion remaining after fevere injuries of the brain? Is it in the corpus callofum? Is this fhewn by the greater mortality of wounds or difeafes in the corpus callofum? Is this body fufficiently connected with the nerves? Are there any experiments which derive from it the fifth, feventh, and other nerves? Does not the fame, or even greater mortality, accompany wounds of the medulla fpinalis? Yet this is not the feat of the foul, fince, though it is compreffed or even deftroyed, the perfon will furvive a long time, with the perfect ufe of all his fenfes. Nay this opinion is oppofed by numerous facts; birds have no corpus callofum; and wounds in that body, are not in the leaft more mortal than thofe in other parts of the brain, as appears from undoubted experiments.

CCCLXXI. Nor does the cerebellum enjoy the prerogative of exciting the vital actions, nor are the provinces of vitality and animality diftinct; nor does the cerebellum generate the nerves of the heart and other vital organs, and the brain thofe which go to the organs of fenfe and voluntary motion. From the cerebellum the fifth nerve is moft evidently produced; but that goes to the tongue, pterygoid, buccinator, temporal, and frontal mufcles, the ear, the eye, the noftrils, all which are parts either moved by the will, or deftined for fenfe. Again, the fame nerve, as the eighth, fends vital branches to the heart and lungs, animal and voluntary ones to the larynx, and fenfitive ones to the ftomach. Laftly, it is not even true, that diforders of the cerebellum occafion death fo certainly and fpeedily. For, from certain obfervations, even of

our own making, it has borne wounds and ſcirrhi, without taking away life; nor is it very different from the brain, being only ſofter and more tender; and, laſtly, we read, and that not very rarely, of wounds of the cerebellum being cured. The power, however, of this part, in exciting convulſions, is ſomewhat greater.

CCCLXXII. Concerning the ſeat of the ſoul, we muſt inquire experimentally. In the firſt place, it muſt be in the head, and not in the ſpinal marrow. For though the latter be affected, the integrity of the mind remains the ſame. Again, it appears, from the experiment of convulſions ariſing when the inmoſt parts of the brain are irritated, that it lies not in the cortex, but in the medulla; and not improbably, in the crura of the medulla, the corpora ſtriata, thalami, pons, medulla oblongata, and cerebellum. Finally, by another not abſurd conjecture, it lies at the origin of every nerve, ſo that the concurrence of the firſt origins of all the nerves, makes up the cenſorium commune. Are the ſenſations of the mind repreſented there, and do the voluntary and neceſſary motions ariſe in that place? This ſeems very probable. For it does not ſeem poſſible, that the origin of motion can lie below that of the nerve; for that would be a gratuitous ſuppoſition of immobility or inſenſibility, in ſome part of the nerve, though perfectly ſimilar to the reſt. Nor can the origin of motion (CCCLXIX.) be placed higher in the arteries, for they neither have feeling, nor are excited to voluntary motion. It therefore follows, that the ſeat of the mind, muſt be where the nerves firſt begin.

CCCLXXIII. We come now to the explanation of the manner in which the nerves are the organs of ſenſe or motion; which, as it lies hid in the ultimate elementary fabric of the medullary fibres, ſeems to be placed above the reach both of our ſenſes and reaſon: but we ſhall endeavour to make

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as great an approximation to the truth as poſſible, by experiments. Firſt, it is demonſtrated, that ſenſation does not come through the membranes from the ſentient organ to the brain, and that motion is not tranſmitted through the coverings from the brain into the muſcle. For the brain itſelf, deeper than theſe membranes, receives the impreſſions of ſenſe, and when injured throws the muſcles into convulſions. Moreover, it is certain, that the nerves ariſe from the medulla of the brain; the truth of which is manifeſt in all the nerves of the brain, more eſpecially in the olfactory, optic, fourth and ſeventh pair, which continue their medullary fabric a long way before they receive the covering of the pia mater.

CCCLXXIV. We muſt, therefore, inquire into the nature of this medulla. It is a very ſoft pulp, harder in inſects and idiots; in other reſpects every where alike. It is diſpoſed, however, to be formed into fibres, or parallel threads, lying upon one another lengthwiſe. This appears from innumerable obſervations, eſpecially in the corpus calloſum, corpus ſtriatum, thalami of the optic nerves, ſpinal marrow, in the brains of fiſhes, and eſpecially in their thalami optici. Again, that the fibres of the brain are continuous with thoſe of the nerves, ſo as to form one continued ſubſtance, appears very evidently in the ſeventh, fourth and fifth pair of nerves. There is a great deal of oil in the medulla, upwards of a tenth part of its whole weight.

CCCLXXV. But here a controverſy begins concerning the nature of this fibre, which, with other ſimilar fibres, compoſes the ſubſtance of the medulla and of the nerves. Many recent philoſophers have ſuppoſed it to be a ſolid thread, and only moiſtened by vapour exhaling into the cellular fabric which ſurrounds the nervous fibres, and that, when it is ſtruck by a ſenſible body, the vibration excited is conveyed to the brain.

CCCLXXVI. But the phenomena of wounded nerves will not allow us to imagine the nervous fibres to be folid. For, if a nerve when irritated, vibrate, (after the manner of an elaftic chord, which trembles when it is taken hold of,) the nerve ought to confift of hard fibres, fixed by their extremities to hard bodies, and tenfe; for chords which are foft, or not tenfe, or not fixed, do not vibrate. But all the nerves, at their origin, are medullary, and very foft, and exceedingly far from any kind of tenfion; and they retain the fame foft texture, and are not covered with membranes, where they pafs through well protected channels, as the intercoftal nerve and the fecond branch of the fifth pair; fome alfo are foft throughout their whole length, whatever fize they may be of: as, for example, the foft olfactory and acouftic nerves, in which laft we would moft readily expect tremor; as in found. Again, although the nerves be hard, they become foft in the vifcera, mufcles, and fenforia, before they act. Therefore, the nervous fibres, being neither tenfe in their origin, nor in their termination, cannot poffibly vibrate in an elaftic manner. But alfo, in particular and moft important cafes, they cannot vibrate; becaufe, through their whole length, they are firmly tied to folid parts, by means of cellular fubftance: for example, the nerves of the heart are tied to the great arteries, and to the pericardium. Finally, that the nerves are totally devoid of elafticity, is demonftrated by the experiment, in which the nerves, cut in two, neither become fhorter, nor draw back their divided ends to the folid parts; but are rather elongated from their laxity, and expel their medulla in form of a protuberance. Befides, the extremely foft medulla of the brain exhibits all the phenomena of pain and convulfions, which are produced by nerves, without any poffibility of tenfion.

CCCLXXVII.

cccLXXVII. Add to this, that the motion of an irritated nerve is propagated downwards, and that mufcles that are feated above the place of irritation, are never convulfed. This is altogether inconfiftent with elafticity; for an elaftic chord propagates its tremors from the point of percuffion, to both extremities. But, if the phenomena of fenfe and motion cannot be explained from the nature of elafticity, the only probable fuppofition that remains is, that there is a liquor which comes from the brain, defcends into the nerves, and flows out to the extreme parts of the body; the motion of which liquor, accelerated by irritation, operates only according to the direction in which it flows; and the convulfions cannot afcend upwards, becaufe of the refiftance made by the frefh afflux of the fluid from the brain. But the fame liquid being put in motion in an organ of fenfe, by a fenfible body, tranfmits its motion upwards to the brain; for then it is not refifted by a contrary fenforial torrent coming from the brain.

cccLXXVIII. It is therefore probable, that the nervous fibrils, and the medullary fibres of the brain, which have the fame nature, are hollow. Nor is the fmallnefs of thefe tubes, which are not vifible by any microfcope, of any force againft the propofed arguments; nor the abfence of fwelling in a tied nerve, which is not exactly true; with other arguments of the like kind, which indeed fhow the weaknefs of our fenfes, but have not any validity againft the real exiftence of nervous fluids. If they are tubes, it is very probable that they derive their fluids from the arteries of the brain.

cccLXXIX. But the nature of this fluid is difputed. Many, efpecially the moderns, will have it to be extremely hard or elaftic, ethereal, or even electrical; but the more ancient opinion is, that it is rather aqueous, incompreffible, and albuminous. Indeed it is not to be denied, that there are many

many arguments against admitting either of these opinions. An electrical matter is, indeed, the most powerful, and fittest for exciting motion; but then it cannot be confined within the nerves, but penetrates throughout the whole animal to which it is communicated, and fills with its energy the flesh and fat, as well as the nerves. But, in a living animal, the nerves only, or such parts as are pervaded by nerves, tremble when irritated; and, therefore, this liquid must be of a nature which permits it to flow through the nerves, and yet confines it within their tubes. Also a ligature on a nerve takes away sense and motion, but does not stop an electrical current.

CCCLXXX. A watery and albuminous nature is common to most of the juices in the human body, and may be therefore readily imagined to exist in the nervous fluid, as indicated by the water which exudes into the ventricles of the brain from the same vessels; by the gelatinons fluid, which flows out in cutting through the brain in fish, and the larger nerves of animals; and by the tumor which arises in tied nerves. But is such a nature capable of explaining the wonderful force of convulsed nerves, observable in the dissections of living animals, even the smallest, and in the great strength of mad and hysterical people? Is the hydrostatic example of capillary tubes of any weight; which, although it may explain the strength in the motion, is nevertheless inconsistent with the celerity?

CCCLXXXI. For, the nervous fluid, which is the instrument of sense and motion, must, be exceedingly moveable, so as to carry the impressions of sense, or commands of the will, to the places of their destination, without any imaginable loss of time, and cannot receive the cause of its motions only from the heart. Moreover, it is very thin and invisible, and destitute of all taste and smell; yet

reparable

reparable from the aliments. It is not on any account to be confounded with that viſible, viſcid liquor exhaling into the intervals of the nervous chords.

CCCLXXXII. That this liquor moves through tubes rather than through the ſpongy and ſolid ſubſtance of the nerves, we are perſuaded from its celerity, and from the analogy of the whole body; of which all the liquids, the fat excepted, flow through their proper veſſels.

CCCLXXXIII. Therefore, upon the whole, it ſeems to be certain, that, from the veſſels of the cortex, a liquor is ſecreted into the hollow tubes of the medulla, which, being continued into the ſmall tubes of the nerves, and propelled to their extremities, is the cauſe both of ſenſe and motion. But there will be a twofold motion in that humour; the one ſlow and conſtant, from the heart; the other not continual, but exceedingly ſwift, which is excited either by ſenſe, or any cauſe, as motions ariſing in the brain.

CCCLXXXIV. The ſame nerves moſt evidently are ſubſervient both to ſenſe and motion; ſo that we are not allowed to adopt two diſtinct ſyſtems of nerves, one motory, the other ſenſitive. If ſenſe ſometimes remains after motion is deſtroyed, this ſeems to be becauſe much more ſtrength is required for the latter. Dying people hear and ſee, when incapable of motion.

CCCLXXXV. What becomes of this nervous fluid, which cannot but be ſecreted in very great abundance, from ſo large a quantity of blood moved with ſuch velocity, if you compare it with the very copious ſecretion from more ſluggiſh blood, and at a greater diſtance from the heart, in the ſmall renal and meſenteric arteries? It is not improbable that it exhales through the cutaneous nerves; the laſſitude, ſupervneing in a few hours both to ſenſation and motion, and its removal by ſpirituous medicines,

medicines, ſhew that this liquid may both be loſt and repaired. Many have thought that it alſo exhales into various cavities of the body; as that of the ſtomach, and inteſtines. We may expect ſome part of it to be abſorbed, that the nobleſt fluid of the body may not be too quickly diſſipated. That it nouriſhes the body, is improbable: it is too moveable to expect adheſion from it: that is the office of ſlow and viſcid fluids.

CCCLXXXVI. What is the purpoſe of ſo many protuberances in the brain; of the ventricles, nates, and teſtes; of the diſtinction of the brain from the cerebellum; and of ſo many tranſverſe chords communicating from one ſide of the brain, cerebellum, and ſpinal medulla, to the oppoſite ſide?

CCCLXXXVII, The diſtinction of parts neceſſary for important uſes, ſeems to have produced the neceſſity of the ventricles. That the corpora ſtriata and thalami might keep their medulla diſtinct, it was neceſſary for a vapour to be interpoſed between them; and the ſame reaſoning is true with regard to the brain and cerebellum. Perhaps, likewiſe, the neceſſity of introducing warmth into the thick medulla of the brain, may have produced the neceſſity of a cavity through which the arteries may enter in great numbers and crowded together. Perhaps alſo it was proper, that, into the inmoſt parts of the brain, ſmall veſſels only, without any large ones, ſhould enter. We may alſo ſuſpect, that the ſoftneſs of the fibres of the brain requires ſhortneſs, in order to ſuſtain their own weight.

CCCLXXXVIII. We are not yet acquainted with the uſes of moſt of the protuberances, and we ought to learn them from diſeaſes, and from anatomical experiments made on animals reſembling man. But we have little hopes of ſucceſs, in parts that are ſo ſmall, ſo deeply ſituated, and hardly ever to be touched, without inflicting a fatal wound. Do ſo many diſtinct provinces of ideas exiſt in them; as in

in the optic thalami? But moſt of theſe protuberances produce no nerves.

CCCLXXXIX. The internal bands and ducts ſeem to make ſome communication of motions, and perhaps of ſenſations. Some of theſe join the brain with the cerebellum; others join the ſpinal marrow with the nerves of the brain, as the acceſſory nerve; and moſt of them join the right and left parts together, as the anterior commiſſure (CCCXLV.) and the two poſterior (CCCL.) the corpus calloſum (CCCXLIII.) the ſtriæ between the proceſs from the cerebellum to the teſtes (CCCLIV.) and the medullary croſs bars, in the bottom of the third ventricle, and in the medulla oblongata and ſpinalis (CCCLV.) For this manifeſtly ſeems to be the reaſon why, as in infinite examples, from an injury of the right ſide of the brain, the whole muſcles of the left ſide of the body become paralytic, and the reverſe although it ſeems unaccountable, that this decuſſation does not always happen. Moreover, by this contrivance, nature ſeems to have provided, that, when any part of the brain is injured, the nerve ariſing from it is not always rendered uſeleſs. For if a nerve receive its fibres, both from its own hemiſphere of the brain, and from the oppoſite one, by communicating bundles, its office may, in ſome meaſure, be continued entire by the fibres which it receives from the oppoſite ſide, after thoſe of its own ſide are deſtroyed. Accordingly, we have numberleſs inſtances of wounds of the brain, even attended with a conſiderable loſs of ſubſtance, which yet have not been followed with permanent injury to any nerve, or to any of the mental faculties. Many of the other appearances, ſuch as the ſmaller ſtripes, reſemblances of nerves, and even protuberances, are produced in the brain from mechanical neceſſity, the pulſation of the veſſels, and the figure of the incumbent parts,

CCCXC.

CCCXC. We have ſaid, that the nerves are the organs of ſenſe and motion: we ſhall therefore proceed firſt to explain motion, becauſe it is more ſimple, uniform and perpetual, as it exiſts in the fœtus before moſt of the ſenſes.

CHAP. XI.

MUSCULAR MOTION.

CCCXCI. THE organ of motion in the human body is not ſingle. And, in the firſt place, in every animal and vegetable ſibre, in hair, feathers, membranes, cellular ſubſtance, in the humid muſcular fibre, and, laſtly, in animal and vegetable gluten, there is a contractile power, by which they both reſiſt extenſion, and, when the extending power is taken away, acquire their former ſhortneſs; nor does this power ever ceaſe endeavouring to bring the elementary particles into the cloſeſt contact the mechaniſm of the part can admit. After death, even for many days, it does the ſame, ſo that the fibres of a divided muſcle contract towards each extremity, and leave a wide gap in the middle; alſo arteries, when divided, contract themſelves in length.

CCCXCII. I call this force dead, becauſe it continues to act after death, and ſo far is different from the powers of life. In the living animal indeed it is ſomewhat more lively; for, both from cold and fear, the ſkin is ſtimulated, ſo that it grows harder, and erected, and along with this hardneſs contracts itſelf in length. Again, the cellular fibres are perpetually endeavouring to ſhorten themſelves, and always tend to their own contraction. Hence, when the ſkin or any other membrane is extended, as ſoon as the cauſe of extenſion is taken off, it returns by a gentle effort to its former ſhortneſs. But it

alſo

alſo reſiſts diſtention in another way, with a perpetual effort; and, by a gentle but continual approximation of its own elements, it propels the contained fat or water, or other bodies accidentally introduced. The ſame power alſo ſeems to limit the excretion of vapour; for when the fibres and plates of the cellular texture are preternaturally relaxed, an immenſe quantity either of fat or of watery humour is depoſited in that texture. This debility ſeems to be the principal cauſe of a true dropſy. The ſame cauſe being always efficacious, and at work in the heart, joints, and every where throughout the body of the embryo, brings into nearer contact the arteries, auricles, and ventricles; produces flexures; and contracts the heart, when in a manner diſſolved, into a cone. By an unknown or hidden power, it alſo ſeems to determine the ſhape of moſt parts of the human body; by expelling the gluten received into the cells, bringing the terreſtrial particles nearer to one another, and giving the proper ſolidity, curvature, and ſituation, to the different parts.

cccxciii. It is the nature of this power to act continually, by a gentle but uninterrupted effort. It is common for it alſo to be excited by poiſons, in every membrane, fibre, and cellular texture; but never by cutting or puncturing with a ſharp inſtrument. Theſe are the proper characteriſtics of the red muſcular fibre. The ſtructure of this fibre it is now neceſſary for us to conſider.

cccxciv. Muſcular fibres in the human body, are bundles of red threads, by which manifeſt motion is performed. When many of theſe fibres are collected together, and are evidently red, they are called a muſcle. The extreme ſimplicity of the fabric has been the cauſe of the obſcurity that prevails in underſtanding how ſmall and ſoft fleſhy fibres can produce, with ſuch ſtrength, moſt exten-

ſive

five motions, both in man, and most especially in the crustaceous insects.

CCCXCV. In every muscle there are fibres, which are long, slender, soft, somewhat elastic, almost constantly parallel on the whole, and, surrounded with a good deal of cellular substance, are collected into lacertuli. These bound together, by loose cellular substance, generally with some fat, unite into larger bundles, which are always divided by cellular bands, and membranous partitions, till at last a number of them, either parallel or inclined, surrounded with a thin cellular membrane, continuous with their partitions, and separated from the neighbouring muscles by some coarser cellular substance, constitute a single muscle. In every visible fibre there appears a series of filaments, which, by oblique extremities being mixed and agglutinated with others of the same kind, are combined into one larger fibre.

CCCXCVI. The generality of muscles, but especially all those which are inserted into bones, and all which are pressed strongly by other fleshy incumbent parts, do not consist of fibres of one kind. For the fleshy fibres (CCCXCV.) being collected together, commonly compose the swelling in the middle of the muscle, which is called its belly: these fibres degenerate by degrees at each end of the muscle, become more slender and hard, and having laid aside their red colour, acquire a silvery splendor, and being compressed closer together, are included in a small quantity of short cellular substance, are coloured with fewer vessels, and become indolent and scarcely irritable: they are denominated tendons if they are collected into a narrow round chord, but if into a broad flat surface, aponeuroses. The cellular texture which covers the whole tendon is called its vagina, and resembles the coat of a muscle. That fleshy fibres actually change into tendinous, is rendered probable by comparing the foetus,

fœtus, in which there are very few tendons, with a young perſon, in whom there are many more; and with an adult or old perſon, in whom are the greateſt number. Muſcles which are not inſerted into any bone, have commonly no tendons, as the heart, the ſphincters, the tongue, and muſcular membranes of the viſcera and veſſels. But thoſe commonly end in long tendons, which are required to paſs round the joints and heads of the bones, and in that extremity which is moſt moveable. In the fœtus the muſcles are evidently inſerted into the perioſteum only; but in adults, where the perioſteum is intimately united with the bone, the tendons being blended with the perioſteum, adhere into the pits of the bone itſelf.

cccxcvii. The tendinous fibres indeed often lie in a ſtraight line with the fleſhy ones, and are, as it were, a continuation of them. But it is not at all rare for the fleſhy fibres to be obliquely inclined to the tendon, and to adhere to it, ſo that it grows thicker in its progreſs by continually receiving new fibres. This is called a pennated muſcle. Other tendons lie in the middle betwixt two plates of fibres, one on each ſide, meeting together in an obtuſe angle downwards. There are inſtances of ſeveral tendons pennated on each ſide, being conjoined into one muſcle. There are alſo other modes of union of the tendinous with the fleſhy fibres.

cccxcviii. Within the cellular tunic that ſurrounds the fibres, the arteries and veins are ſubdivided into rectangular reticulations, for the moſt part accompanying and contiguous to each other; thence the vapour and fat effuſed into the coarſe and fine cellular ſubſtance; thence their abſorption. Lymphatic veſſels run along the muſcles of the tongue, neck and face, but are difficultly demonſtrated in the limbs. Along with the blood-veſſels, nerves are alſo diſtributed through the cellular ſubſtance of the muſcles, more numerouſly than to other

other parts of the body, except the eye; they lay aſide their hard involucrum, become ſofter and vaniſh before they can be traced to their ultimate extremities. They enter the ſame muſcle in many parts, without preference to any particular one. In the tendons they cannot be demonſtrated. Nor are there any nervous fibres which ſurround and conſtringe the muſcular lacerti. Thoſe who have deſcribed them ſaw nothing but cellular ſubſtance.

CCCXCIX. The ſtructure of the ultimate fibre, conſidered as the elements of a muſcle, when inveſtigated by the microſcope in man and other animals, has always appeared ſimilar to the ſtructure of the larger fibres; and except very minute filaments, connected by cellular ſubſtance, nothing upon which we can rely has been obſerved. There is no ſeries of veſicles or chain of rhombs. Are theſe fibres hollow? Are they continuous with the arteries? Does the difference betwixt muſcular and tendinous fibres conſiſt in the latter being rendered ſolid by being compreſſed and having their fluids expelled? That the blood is not concerned, is proved by the ſlenderneſs of the fibres, which are ſmaller than the blood globules, by the whiteneſs of the muſcles, after the blood is waſhed from them, and by phyſiological reaſons (CCCCXI.) And, in general, more ſtrength may be expected from a ſolid fibre.

CCCC. A muſcle is endowed at leaſt with a threefold power. Firſt, the dead one, common to it with other animal fibres. Then another, which we have called the vis inſita, poſſeſſing different phenomena. For, in the firſt place, it is peculiar to life, and to the firſt hours after death, and it diſappears much ſooner than the dead one. Again, in moſt caſes, its action conſiſts in alternate oſcillations; ſo that moving to and fro, at one moment it contracts itſelf towards the middle; and at the next,

next, extends itſelf from the middle towards the extremities, and ſo on ſucceſſively for ſeveral times. Moreover, it is manifeſt, quick, and performs very conſiderable motions; the dead force, only ſuch as are ſmall and ſcarcely apparent. It is excited both by the touch of a ſharp inſtrument, and in the hollow muſcles by inflated air, by water, and every kind of acrimony, but more powerfully than by any other ſtimulus by electricity. Laſtly, it is peculiar to the muſcular fibre, and in no other part of the human body is it found poſſeſſed of the qualities above mentioned. But its phenomena deſerve to be more particularly explained.

CCCCI. It is natural to every muſcle to ſhorten itſelf, by retracting its extremities towards its belly or middle. In order to diſcover the moving power from the fabric which we have deſcribed, it will be of uſe to conſider the phenomena of muſcular contraction. Every muſcle when in action becomes ſhorter and thicker. This contraction of its length is various; leſs in ſome, more in others; and in particular inſtances very conſiderable, for example, in ſome of the ſphincters, iris, diaphragm and intercoſtals, inſomuch that it appears that the length of a muſcle may be contracted much more than one third, which computation was derived from an erroneous hypotheſis.

CCCCII. The inteſtines are exceedingly tenacious of their vis inſita; they continue to contract, after they are taken out of the body, and even after they are cold. The heart is even more tenacious than theſe, if you conſider all things; as is moſt evident in the chick, and in cold blooded animals. Different muſcles are moſt readily excited, by different ſtimuli; as the bladder by urine, the heart by the blood, and the inteſtines by air. Though their nerves are removed, on their connexion with the brain cut off, muſcles loſe but little of their irritable nature. It appears alſo, that this irritable

diſpoſition

difpofition is very widely extended through the animal fibre, from the examples of polypi and other infects, which have neither brain nor nerves, and yet are exceedingly impatient of any ftimulus; and from the analogy of plants, of which very many flowers and leaves open or contract, according to the various degrees of heat and cold, fome even fo quickly, that they are nothing inferior in this refpect to animals. This power is totally different from any other known property of matter, and is new. It does not depend either upon gravity, or attraction, or elafticity, for it is inherent in foft fibres, and is deftroyed, when they become indurated.

CCCCIII. But that a caufe of motion is conveyed through the nerves into the mufcles, is certain from the obfervations, already noticed (CCCLXVII. et feq.) For the nerve alone poffeffes feeling; alone conveys the dictates of the mind; and neither retains any influence over, nor receives any perceptions from any part, whofe nerve is either tied or cut, or which has no nerve. On irritating the nerve or fpinal marrow, even in a dead animal, the mufcle or mufcles, which have nervous branches from thofe parts, are moft violently convulfed. When the nerve of any mufcle is cut or tied, or the part of the fpinal marrow, or brain, from whence the nerve has its origin, is compreffed, the mufcle becomes paralytic and feeble, and cannot by any power be recalled into action fimilar to the vital one. But if the compreffion be removed from the nerve, the mufcle recovers the power by which it is put into action. When the nerve is irritated below the place where it is cut, the mufcle to which that nerve belongs is contracted. Numerous experiments have been made, to prove this, efpecially on the phrenic and recurrent nerves.

CCCCIV. This power is not the fame with the vis infita. The former is adventitious to the mufcle; whereas the latter is inherent in it. The former

ceafes along with life; whereas the latter, according to certain experiments, fubfifts long after it. The former is fuppreffed, by tying a ligature upon the nerve, by injuring the brain, or by the exhibition of opium. The latter is not affected by thefe circumftances, but continues after the nerve is tied or cut, and even in the inteftines, though taken out of the body; it alfo exifts in animals deftitute of brain: parts of the body poffefs motion, which are deftitute of fenfation, while others poffefs fenfation, which are deftitute of motion. The will excites and removes the nervous action, but has no power over the vis infita.

CCCCV. In mufcular action, whether proceeding from the vis infita, or from the nervous power, the fibres are contracted towards the middle of its belly, and expand outwards: they are varied by tranfverfe wrinkles, and the whole mufcle becomes fhorter, and draws its extremities towards its centre, and therefore carries towards each other thofe parts with which it is connected, in the reciprocal proportion of their firmnefs. Mufcles, during their contraction, fwell, and at the fame time become hard, and, as it were, increafe their circumference every where. I have never obferved them to turn pale. Whether, on the whole, they are increafed in bulk, and acquire more in breadth than they lofe in length, is difficult to be known. They draw after them the paffive tendons, which of themfelves are neither moveable or irritable. The whole of a mufcle may be moved at once, or only a part of it: if one extremity is fixed to an immoveable part, that only is moved, which is capable of yielding.

CCCCVI. Do the arteries contribute in any way to mufcular motion, as indicated by the paralyfis of the lower extremities, produced by tying the aorta? Not at all, unlefs by preferving the integrity of the mufcles, and mutual relation of the parts, by fecreting vapour and fat, and by nourifhing them. For

by dividing or tying its artery, a mufcle does not become paralyfed, unlefs after a confiderable time, when the mufcles begin to be deftroyed by gangrene. The irritation of the artery has no effect on the mufcles. Moreover, it is impracticable to explain the motion of peculiar mufcles from a caufe, which, proceeding from the heart, operates with equal force on all parts of the body. Laftly, the influence of the will is confined to the nerves, and does not extend to the arteries or other folid parts of the body.

CCCCVII. But the manner in which the nerves excite motion in the mufcles, is fo obfcure, that we may almoft defpair of difcovering it. And we do not even attempt to inveftigate the vis infita, which feems to be an increafed attraction of the elementary parts of the fibre, by which they mutually approach each other, and accumulate contortions in the middle of the fibre. This force of attraction, which is implanted by nature in the moving fibre, is excited and increafed by ftimuli. The reft is mere hypothefis. As to nervous veficles fwelling by a quicker influx of the nervous fluid, they are inconfiftent with anatomical truth, which demonftrates the fibres to be cylindrical, and in no part veficular; and likewife with the celerity with which mufcular motion is performed, and with the bulk of a mufcle being rather diminifhed than increafed during its action. The chains and rhombs of the inflated fibres are in the fame manner repugnant to anatomical infpection, and to the celerity; they would alfo occafion an immenfe wafte of power, and render the mufcle but little fhorter. The nerves want that irritable nature which is obferved in the mufcular fibre; and befides, it is by no means demonftrable, that the fibres, fo numerous, can arife from nerves, fo few and diftributed in a different direction, almoft tranfverfely with refpect to the mufcular fibres. The idea of nerves being difpofed round

arterial

arterial fibres, compreffing them by their elafticity, is founded upou a falfe ftructure of the fibre, which is gratuitoufly affumed to be filled with blood, and fuppofes nerves, where cellular fibres only can be demonftrated. Moreover, the phenomena of animals, which have neither brain or nerves, and are yet very capable of motion, demonftrate the fabric of the mufcles to be fufficient for their motion, even without nerves. Blood globules, filled with air, and the explanations derived therefrom, fuppofe a falfe nature of that fluid; namely, that elaftic air exifts, where it does not (CCLXXXI.) The animal fpirits are not of the nature of electricity.

CCCCVIII. If we may add any thing to the phenomena, we may fuppofe the nervous liquor to be of a ftimulating nature, forcing the elementary particles of the mufcular fibre to approach nearer to each other. The motive caufe which occafions the influx of the fpirits into the mufcle, fo as to excite it into action, feems not to be the foul, but a law eftablifhed by the Creator. For animals, newly born, or newly transformed, without any attempt, or exercife, know how to perform compound motions, very difficult to be defined by calculation. But the foul learns thofe things, which it performs, flowly, imperfectly, and experimentally. Mufcles, therefore, contract, which in a given time receive more of the nervous fluid, whether that be occafioned by the will, or by fome irritating caufe arifing in the brain, or applied to the nerve.

CCCCIX. Though the foul may be fuppofed to act in nervous motions, it cannot be admitted in thofe arifing from the vis infita. The heart and inteftines, alfo fome organs of the venereal appetite, are governed by the vis infita, and by ftimuli. Thefe powers do not arife from the will; nor are they leffened, or excited, or fuppreffed, or changed by it. No cuftom or art can fubject thefe organs of inherent motion to the will, or caufe a fatellite of vol-

untary motion to forget to obey the commands of the ſoul. It is ſo certain, that motion is produced by the body alone, that we cannot even ſuſpect any motion to ariſe from a ſpiritual cauſe, except that which the will ſeems to excite in animals; and, even in the very organs of animal volition, a ſtimulus will occaſion the moſt exceſſive actions, in direct oppoſition to the will.

ccccx. There ſeems to be this difference between the muſcles obeying the will, and thoſe which are governed by the vis inſita, that the latter are more irritable, and are very eaſily excited into action by a gentle ſtimulus; as, for inſtance, the heart and inteſtines; which organs are moſt manifeſtly, and greatly, and conſtantly, irritable. On the other hand, the muſcles which obey the will, are leſs eaſily, and leſs durably irritable. Hence, they either need the agency of the will, or of a powerful ſtimulus; by which, indeed, even theſe may be excited to action, independent of the will. Thus, it happens, that, in apoplexy, the muſcles which obey the will, being deprived of all influx from the brain, languiſh, and become paralytic; while the vital muſcles, having no occaſion for the operation of the brain, continue to be excited into contraction by their ſtimuli; the heart by the blood, and the inteſtines by the air and aliments.

ccccxi. The ſtrength of this action is very conſiderable in all perſons, but more eſpecially in madmen, and in ſome ſtrong men; ſince frequently, with a few muſcles only, they will raiſe a weight, much greater than that of the whole human body. But even in healthy people, very ſlender muſcles have elevated 200 or 300 pounds. The muſcles of the back will even ſuſtain 3000. Notwithſtanding this, much the greater part of the force or power exerted by a muſcle, is always loſt, without producing any viſible effect. For all muſcles are inſerted nearer the fulcrum, than the weights are appended;

ed; and therefore their action is leſſened, in proportion as their lever is ſhorter than that of the weight. Moreover, moſt of the muſcles are inſerted into the bones, eſpecially in the limbs, at very acute angles; whence, again, the effect which a muſcle exerts in action, is proportionably leſs than the effort which it exerts, as the ſine of the angle intercepted betwixt the bone and the muſcle, is leſs than the whole ſine. Again, the half of every muſcular effort is loſt, becauſe it may be conſidered as an elevating cord, drawing an oppoſite weight to its fixed point. Beſides, many of the muſcles are ſeated in the angle between two bones, ariſing from the one, and moving the other; and therefore, on that bone being moved, they are bent, and, like inflected cords, require a new force to extend them. Many of them paſs over ſeveral joints, each of which they bend in ſome degree, ſo that only a ſmall part of their effort remains to bend their proper joint. The fleſhy fibres themſelves of the muſcles very often form angles with their common tendon, whence a great part of their force is again loſt, and only that proportion of the whole remains, which is as the ſine of the angle of their inſertion to the whole. Finally, the muſcles move their oppoſed weights with very great velocity and eaſe, ſo that they not only overcome the equilibrium, but likewiſe add a conſiderable exceſs of velocity.

ccccxii. All theſe loſſes of power being computed, make it evident, that the force exerted by muſcles in action, is exceedingly great, and totally different from any mechanical proportion; ſince the effect is ſcarce $\frac{1}{60}$ of the whole force exerted by the muſcle, and yet a few muſcles, weighing but a few pounds, are able not only to raiſe ſome thouſands of pounds, but alſo with very great velocity. Nor is this to be reputed any defect of wiſdom in the Creator: for all thoſe loſſes of power were rendered neceſſary, on account of the ſymmetry

ſymmetry of the body, of muſcular motion, and of the requiſite celerity and direction; whereas the contrary of all theſe is required in the mechaniſm of machinery. We may, however, certainly conclude from hence, that the action of animal motion is very powerful, ſince, in a ſmall organ, it can exert a force equal to ſome thouſand pounds for a conſiderable time, or even for entire days; nor does this ſeem to be otherwiſe explicable, than by the incredible celerity with which the influx of this fluid obeys the command of the will. But from whence this velocity proceeds, we are unable to ſay, and muſt reſt ſatisfied with knowing that there exiſts a law, by which, at a given volition, a given celerity is produced anew in the nervous fluid.

CCCCXIII. The equilibration of muſcular motion is aſſiſted by the action of antagoniſt powers. Namely, in all parts of the human body every muſcle is counterpoiſed by ſome counteracting weight, or by elaſticity, or by muſcles, or by a fluid which reacts upon hollow muſcles, by which it is expelled. This cauſe is the vis inſita, and operates continually, even while the muſcle acts; and ſo ſoon as the additional celerity derived from the brain remits, its action reſtores the limb or other part immediately to its former ſtate, in which there is an equilbrium betwixt the muſcle and its oppoſing cauſe. Whenever muſcles conſtitute the antagoniſt power, none of them can contract without extending their antagoniſts, by which the nerves being diſtended, and a ſenſe of uneaſineſs produced, a ſtill ſtronger endeavour towards reſtoring the equilibrium is excited. Hence, when a flex or muſcle is divided, the extenſor operates even in the dead body; and the reverſe.

CCCCXIV. But there are acceſſory means, by which the motions of the muſcles are rendered ſafe, certain and eaſy. The large long muſcles, by which the greater flexions are performed, are included in firm

firm tendinous ſheaths, which are drawn and tightened by other muſcles; for thus, while the joint is bent, the muſcle, though in a ſtate of contraction, remains preſſed againſt the bone, and a conſiderable loſs of power is avoided. But the long tendons, which are incurvated or extended over joints which are bent when they are moved, are received within proper braces, which have lubricated canals hollowed out in them, and which, at the ſame time that they do not interrupt their motion, keep the tendons ſteady, ſo that they neither can be diſplaced, nor get rigid under the ſkin, with pain and loſs of motion. In theſe tubular braces, a proper liniment is poured around the tendons. The ſame office is performed in ſome ſituations by perforated muſcles themſelves. In other parts, the tendons are either carried round eminences of bone, in order that they may be inſerted at greater angles into the bone which they move; or they are inſerted into another bone, from whence a different tendon deſcends under a much larger angle into the bone to be moved. In other parts, nature has carried the muſcles derived from convenient ſituations, in a contrary direction into the part to be moved, as it were round a pully. She has likewiſe ſurrounded the muſcles on all ſides with lubricating fat, both the fibrils, fibres, lacerti and muſcles; which fat, being compreſſed and effuſed amongſt the tumid muſcles and fibres, anoints the fibres, and preſerves their flexibility.

CCCCXVI. Moreover, the effect of one muſcle is determined by the co-operation or oppoſition of others, which either hold firm the part from which the muſcle ariſes, or bend it, or elſe, by the concurrence of their action, change the action of the muſcle from its ſtraight courſe to its diagonal. Muſcles alſo aſſiſt each other, even though ſituated at a conſiderable diſtance, by the one keeping the bone ſteady, out of which the other ariſes. There-
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fore, the action of no muſcle can be underſtood from conſidering it alone; but all the others muſt likewiſe be conſidered at the ſame time, which are either inſerted into the muſcle itſelf, or into any of the parts to which the ſaid muſcle adheres.

CCCCXVII. By theſe muſcles variouſly conſpiring and oppoſing each other, are performed walking, ſtanding, flexion, extenſion, deglutition, and all the other functions of human life. But the actions of the muſcles are alſo generally uſeful. They accelerate the return of the venous blood, by compreſſing both the contiguous veins between the tumid muſcles, and the veins proper to the muſcles between their turgid lacerti, and by the force of that preſſure being determined by the valves towards the heart only, they aſſiſt the powers of the heart: they likewiſe return the fat to the blood; and agitate, and triturate the arterial blood, and ſupply it more quickly to the lungs. They influence the ſecretions and excretions, retarding or accelerating them; in the liver, meſentery, womb, &c. they promote the courſe of the contained blood, bile, and other juices, and leſſen the danger of their ſtagnation: they increaſe the ſtrength of the ſtomach, by the addition of their own, whereby digeſtion is promoted; inſomuch that all ſedentary and inactive courſes of life are contrary to the appointment of nature, and prediſpoſe to diſeaſes ariſing from ſtagnation of the fluids, and crudity of the aliaments. The large muſcles, which are placed round the belly, propel the blood contained in that cavity, and preſs it towards the heart. But by much action, the muſcles themſelves become indurated and tendinous, and they convert the cartilaginous and membranous parts upon which they are incumbent, into a bony nature; they increaſe the inequalities and proceſſes of the bones, and excavate the ſides contiguous to them; they obliterate the cells ſeat-

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ed in the diplöe, and bend the bones towards themſelves.

CCCCXVIII. Muſcles which are not excited by a ſtimulus, or for which the mind has no occaſion, become relaxed and ſoft; their wrinkles are ſmoothed out, their fibres are rendered longer, receding from the middle towards the fixed extremities; and the whole muſcle collapſes; the acceſſory cauſe of contraction, whatever it is, is removed; while that remains without which the muſcle never is, as long as it is alive. Nor is there any occaſion for antagoniſt muſcles, although they may aſſiſt. It has been aſked, What becomes of the ſpirit that is ſent from the brain? A part of it perhaps is exhaled; I ſuſpect a part to adhere to the fibre; and that this is the reaſon, that by exerciſe the muſcles grow ſtronger, and the limbs become thicker.

CHAP. XII.

TOUCH.

CCCCXIX. THE other office of the nerves and brain is ſenſation; that is, to ſuffer changes from the impreſſions of external ſubſtances in the parts of the body affected by them, and to undergo analagous changes in the repreſentations in the mind. We ſhall, therefore, firſt examine each of the ſenſes in particular; and then conſider what is common to all of them, and what happens in the mind from the changes in the organs of ſenſe.

CCCCXX. Touch is underſtood in a twofold manner. For, by this term, in general, we call every change of the nerves, ariſing from heat, cold, roughneſs, ſmoothneſs, weight, moiſture, or dryneſs in external bodies, in whatever part of the body that change may ariſe. In this acceptation, touch is aſcribed

cribed to almoſt all parts of the human body, in a greater or leſs degree; as in different places of the body the nerves are more numerous, bare, or covered with thinner membranes; and in this ſenſe pain, pleaſure, hunger, thirſt, anxiety, itching, and the other ſenſations, belong to the ſenſe of touch.

CCCCXXI. But, in a ſomewhat different and more proper acceptation, the ſenſe of touch is ſaid to be the change from external bodies which is produced in the ſkin, more eſpecially at the ends of the fingers, and is repreſented to the mind. For, by the fingers, we moſt accurately diſtinguiſh the tangible qualities of bodies.

CCCCXXII. Indeed, in the ſkin we do not eaſily diſtinguiſh any particle which does not feel. But ſince the touch is commonly aſcribed in a peculiar manner to the papillæ, the ſtructure of the ſkin muſt be deſcribed. What is ſtrictly called the ſkin, is compoſed of a denſe web of very compact cellular ſubſtance, whoſe fibres are intermixed and interwoven, which renders it highly extenſible, contractile, and porous. Its ſtrata, which are expoſed to the air, and next to the epidermis, are more cloſely compacted; as they approach the fat, they are gradually relaxed, and reſolved into a ſofter cellular texture. It is more tender in ſome places, and in others firmer. It is pervaded by many ſmall arteries, which come from the ſubcutaneous ones: they are neither large nor long, but are numerous in ſome parts where the ſkin is red, as in the cheeks; in other parts they are fewer in number. The veins ariſe in great numbers from the ſubcutaneous reticulations: the nerves likewiſe in the ſkin are very numerous; but they vaniſh ſo ſuddenly, that it is very difficult to trace their ultimate extremities. Betwixt the ſkin and muſcles, there is cellular ſubſtance, into which the ſkin inſenſibly reſolved, degenerates, in moſt parts repleniſhed

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with fat, of which the little eminences form pits in the ſkin; but in ſome parts, as the penis, red part of the lips, &c. it is deſtitute of fat. There are very few parts in the human body where muſcular fibres are immediately contiguous to the ſkin, without any ſeparation by fat; for the dartos is only cellular ſubſtance, and has no muſcular fibres. There are ſome places where tendinous fibres are inſerted into the ſkin; as in the palms of the hands, and ſoles of the feet.

ccccxxiii. Throughout the ſkin in general, in moſt parts of the body of man or of the larger animals, on removing the epidermis, ſcarcely an unevenneſs is perceptible, unleſs very minute granulations, raiſed hardly any viſible height, and obtuſe. But in the ends of the fingers, papillæ, ſomewhat larger, but ſtill very difficult of demonſtration to the ſight, are ſeated in cavities of the cuticle, and receive nerves ſcarcely viſible; they are minute projections, formed of veſſels with one or more ſmall nerves, wrapped up in cellular ſubſtance. In the lips, after maceration, they appear long and villous; in the penis they are flaky; and in the tongue they are moſt evident, from the fabric of which we conclude, by analogy, with reſpect to the other cutaneous papillæ.

ccccxxiv. The ſkin is ſurrounded by another covering, which reſiſts completely the action of the air, and which coheres with the ſkin by an infinite number of ſmall veſſels, and by hairs paſſing through it. The outer ſurface of this covering, of a corneous nature, dry, inſenſible, not ſubject to putrefaction, deſtitute of veſſels and nerves, wrinkled in a particular manner, and reticular towards the ſkin, is called the epidermis. It is perforated by an infinite number of pores, of which the larger ones are perſpirative, and the ſmaller vaporiferous, and is connected with the ſkin by numerous minute veſſels reſembling down. By preſſure or burning,

ing, the cuticle grows thicker, by the addition of new plates, formed between it and the ſkin; and is then ſaid to be callous. But even without diſeaſe, in negroes the two plates are diſtinct.

CCCCXXV. The inner ſurface of the cuticle, more ſoft, pulpy, half fluid, reſembling concreted mucus, is ſeparated with difficulty in Europeans, but eaſily in the African negro, in whom it is truly membranaceous, ſolid, and ſeparable; and in the palate of brutes. It is incumbent on the ſkin, of which it receives the papillæ into ſoft pits. It is called the rete Malpighianum, although it be certain that it is not perforated in a conſpicuous manner, as a ſieve.

CCCCXXVI. That this reticular body is compoſed by the concretion of ſome fluid, tranſuding from the ſkin, ſeems very probable. The fabric of the cuticle is ſtill uncertain; for ſince it is deſtitute of veſſels, is regenerated, and is inſenſible, it does not ſeem to belong to the organical parts of the body. Is it the outer part of the Malpighian mucus (CCCCXXV.) coagulated and condenſed by the air and by preſſure; which is perforated in many places by exhaling and inhaling ducts, the mouths of which are cemented together by the interpoſed condenſed glue? Is this opinion ſupported by the mucous expanſion upon the membrane of the tympanum; by its diſſolution in water, as obſerved by eminent anatomiſts, though by others denied, in the cuticle of negroes?

CCCCXXVII. Moreover, to the hiſtory of the ſkin belong the ſimple glands, which are ſeated in very many places under the ſkin in the cellular ſubſtance, and perforate it by their excretory ducts, and pour out upon the cuticle, in the hairy ſcalp, and in the convex ſurface of the ear, a fat ſoft half fluid liniment. Other ſebaceous glands, partly ſimple, and partly compound, generate in the face, though more ſlowly, a dry white liniment, but in the

the groins and armpits one more oily, with which the ſkin being anointed, ſhines, and is defended both from the air and from friction. They are found in all parts of the human body that are under the neceſſity of being more immediately expoſed to the air, as in the face, where there are a great number of the compound ſort; or wherever the ſkin is liable to great friction, as in the breaſts, armpits, groins, glans penis, nymphæ, anus and hams. They frequently ſend out hairs. Are follicles of this kind ſeated in all parts of the ſkin? Although anatomy does not demonſtrate them, yet it ſeems probable that they are preſent every where, as appears from the ſordes, collected about the whole ſurface of the body, ſeemingly of the ſebaceous kind. But another ſort of oily ointment (ccix.) is poured out upon the ſkin, through its pores, from the fat itſelf, without the intervention of glands, eſpecially where the ſkin is clothed with hair.

ccccxxviii. The hair and nails are alſo appendages to the ſkin. The former are ſcattered over almoſt the whole ſurface of the body, the palms of the hands and ſoles of the feet excepted; in moſt parts ſhort and ſoft; but longer upon the ſkin of the head, cheek, chin, and breaſt in men; alſo, upon the forepart of the limbs, in the armpits, groins, and pubis. They ariſe from the ſubcutaneous cellular ſubſtance, originating from a little bulb, which is membranous, ſtrong, vaſcular, of an oval ſhape, and more lax towards the cellular texture, at which part it is alſo furniſhed with veſſels; in which little bulb another bulb lies hid, roundiſh at its beginning, but afterwards cylindrical, and ſurrounded with blood. In this ſecond bulb lies the hair, covered with a fatty humour. The hair, with both its cylindrical ſheaths, arrives at a cutaneous pore, goes out through it, and forces the epidermis into a ſimilar ſheath; whence the very great ſtability of the hair: after this the ſheath cannot be any longer ſeparated from

from the cortex; the filaments, and ſpongy and cellular matter, are continued throughout the whole length of the hair. The hairs grow naturally in the ſubcutaneous cellular ſubſtance; but, by diſeaſe, they are ſometimes formed in other ſituations within the fat. They grow continually; and when cut, are renewed by the protruſion of their medullary ſubſtance from the ſkin outwardly, and by the prolongation of the cuticle. In old age, the hairs, deſtitute of this medulla, dry up, ſplit, and fall off. Their colour is from the juice, which fills the internal cellular texture. They ſeem to exhale through their extremities, and poſſibly throughout their whole ſurface, as we may conclude from the conſtant protruſion of their medulla, which ought to have an end from the plica Polonica, and from the luminous rays that come out from the hairs of an animal electrified. The ſubcutaneous fat follows the courſe of the hairs, and is exhaled.

ccccxxix. The nails are of the nature and fabric of the cuticle, and fall off along with it, being in like manner inſenſible, and capable of reproduction. They are found upon the end of the fingers and toes, occupying their upper and back part, and correſpond to the tactile papillary apex, which they ſupport, and retain applied to the object felt. They ariſe from a ſquare root, between an internal ſtratum of the ſkin, mixed with perioſteum, and another external ſtratum, a little beyond the laſt articulation: they go out by a lunar cleft in the external plate of the ſkin, where the cuticle partly returns back towards the root of the nail, to which it adheres, and is partly laid over the outſide of the nail, and extended forward with it, forming its outer covering. The nail itſelf is ſoft when it is firſt produced, and in the part covered by the ſkin; but, by age, and contact with the air, it becomes harder, corneous, ſolid, and elaſtic, compoſed of long fibres cemented by gluten, ſeparated by ſulci,

fulci, fiffile, and of many layers. The nail thus formed, extends itfelf to the extremity of the finger; and, through its whole extent, its internal ftriated furface is lined by furrowed fkin, blended with periofteum, of which the filaments are firft fhort, afterwards longer, and thofe which adhere near the point of the nail are the longeft of all. Thefe are moft intimately connected with the root of the nail. Beyond the adhering part of the nail, the fkin again becomes free and unconnected with the nail, and has its own epidermis. A furrowed network is interpofed betwixt the fkin and nail, which is feparable and foft, for the protection of the papillæ; where the furrows are, it becomes gradually harder, fo that at laft it can fcarcely be diftinguifhed from the nail. The tendons do not reach fo far as the nail.

ccccxxx. The fubcutaneous cellular fubftance in very few places is without fat, on account of the neceffary motion of the fkin. Where it is replenifhed with fat, it defends the warmth of the internal parts from the air; it renders the fkin moveable upon the mufcles; it fills up the cavities between the mufcles themfelves; and contributes to the whitenefs and beauty of the body. The fkin, Malpighian mucus and cuticle, not only cover the external furface of the body every where, but likewife, where they feem to be perforated, returning inwards they gradually change their appearance. For the cuticle is manifeft in the anus, urethra, vagina, cornea of the eye, auditory paffage, mouth and tongue; nor is it wanting even in the ftomach itfelf and inteftines; although, by the perpetual emollition, its fabric be altered, and relaxed into their villous coat. Thus the true fkin, being continuous with the internal fabric of the palate, tongue, pharynx, noftrils, vagina, &c. changes every where into the white, thick, pulpy, commonly called nervous, coat of thofe parts.

ccccxxxi.

CCCCXXXI. What has been hitherto advanced, is ſufficient to enable us to underſtand the nature of touch. The papillæ at the ends of the fingers, ſomewhat larger in the inſide, beautifully diſpoſed in ſpiral folds, probably ſomewhat erected by the attention of the mind, as appears from ſhiverings, from the nipples of women, from the prolapſus of an inteſtine, from the handling of tangible objects, and from gentle friction, receive the impreſſion of the object on their nervous fabric, and tranſmit it to the trunks of the nerves, and to the brain. This is the ſenſe of touch. It enables us to diſtinguiſh chiefly the roughneſs of objects; and has been poſſeſſed to ſo exquiſite a degree by ſome perſons, that they have been known to diſtinguiſh coloured ſurfaces by the touch alone. We perceive heat, when external bodies are warmer than our fingers; and weight likewiſe, when they gravitate more in compariſon with their bulk than uſual. Humidity we judge of by the preſence of adhering water; ſoftneſs, by the yielding of the object; hardneſs, by the yielding of the finger; figure, by the hard limits circumſcribing them; diſtance, by an inaccurate calculation derived from experience, to which the length of the arm ſerves as a meaſure, &c. Touch corrects the errors of our other ſenſes, although it ſometimes errs itſelf, and though other ſenſes, independent of touch, furniſh animals with juſt perceptions.

CCCCXXXII. The mucous body of Malpighius moderates the action of the object touched, and preſerves the integrity and ſoftneſs of the papillæ. The cuticle excludes the air from the deſtructible ſkin; moderates the impreſſions of bodies, ſo that they may be only ſufficient to affect the touch, without cauſing pain: and, therefore, when thickened by uſe, the ſenſe of feeling is loſt; but, if it be too ſoft, the touch becomes painful. The hairs defend the cuticle from friction, generate and preſerve the heat,

heat, conceal ſome parts, and render the membranes of others irritable, which require to be defended againſt the entrance of inſects; and perhaps they excrete ſomething excrementitious, and afford a paſſage to the exhaled oil. The nails are ſubſervient to the touch, by reſiſting the object touched, ſo as to prevent the papillæ from yielding, and being bent back; they increaſe the power of apprehenſion, and aſſiſt in the handling of minute objects. In moſt animals, they ſerve as weapons of offence; and would be of the ſame uſe to man, if they were not cut.

CCCCXXXIII. Theſe are not all the uſes of the ſkin. For a moſt important office of that covering is to exhale from the body a large quantity of humours, and to abſorb others from the air. Accordingly, the whole ſurface of the ſkin, by an infinite number of ſmall arteries, both prolonged into the papillæ, and ſeated in the ſkin itſelf, exhales a vapour which exudes through correſponding pores of the cuticle; but when the poſition of the veſſels is changed, it is effuſed between the cuticle and ſkin. Theſe arteries are eaſily demonſtrated by injecting water or iſinglaſs into the arteries; for then, from all parts of the ſkin, an infinite number of ſmall drops exude, which being effuſed under the cuticle, rendered impervious by death, raiſe it up in bliſters.

CCCCXXXIV. During life, this exhalation is demonſtrated in many ways. A bright mirror, when held near the warm and naked ſkin, is quickly obſcured by a moiſt vapour. In ſubterraneous caverns, where the air is denſer, it moſt evidently eſcapes into the air, from the whole ſurface of the body, in the form of viſible and thick clouds.

CCCCXXXV. In man, and in ſome, though not in all animals, whenever the motion of the blood is increaſed, while at the ſame time the ſkin is hot and relaxed, from the ſmall cutaneous pores, inſtead of an inviſible vapour, ſweat exudes in the

form of minute, but viſible drops, which, with others of the ſame kind, run together into larger drops. The hotteſt parts are moſt ſubject to ſweat, as the head, breaſt, and folds of the body. The experiment before mentioned (CCCCXXXIII.) together with the ſimplicity of nature, the viſible denſity of the cutaneous and pulmonary exhalation (CCCCXXXIV.) perſuades us, that ſweat is diſcharged through the ſame veſſels which are the organs of perſpiration, and that it differs only in its quantity and celerity, and by the admixture of the liquor of the ſebaceous glands (CCCCXXVII.) and the ſubcutaneous oil, which being diluted by the more plentifully ſecreted arterial fluid, exude of an oily and yellow conſiſtence, and chiefly cauſe the ſmell and colour of the ſweat. Hence, it is more fetid and yellower in the armpits and groins, where thoſe glands are moſt numerous. Both blood and ſmall ſand have eſcaped from the ſkin along with the ſweat.

CCCCXXXVI. The nature of perſpiration muſt be inveſtigated by experiments, and by its analogy with the pulmonary exhalation, which, in like manner, but more frequently becomes viſible in a cold air. That this exhalation is chiefly water, has been proved by experiments, in which the breath, being received into large veſſels, has condenſed into watery drops. This is confirmed by the tenuity of the cloud on the mirror, and its volatility, and by the familiar change of the perſpired matter, when obſtructed, into a diureſis or diarrhœa, and from the eaſy determination of warm liquors to aſſume the form of perſpiration by heat, or of urine by cold. This water is derived from our drink, which furniſhes a great part of the perſpiration, and from inhalation. Frequently, even the odours of our aliments may be plainly perceived in the perſpiration; there is alſo an admixture of the electrical matter in every perſon, and in ſome it is evidently lucid.

CCCCXXXVII. That it alſo contains ſome volatile particles of an alkaline nature, is evident, both from the nature of our blood, and from the conſiderable evils which ſucceed the retention of the perſpiration, moſt conſpicuouſly in acute diſeaſes, when, by being repelled inward, it renders the urine pale, and from the corruption of the air by reſpiration. This volatile alkaline matter ariſes from the particles of the blood, attenuated by perpetual heat and trituration, and changed into an acrimonious nature. Dogs trace theſe odours, and could not know their maſters unleſs ſomething of a particular nature were perſpired from each perſon.

CCCCXXXVIII. The quantity of the matter perſpired is very large, whether we conſider the extent of the organ ſecreting it, the quantity of vapour exhaled by the lungs alone, or the experiments of Sanctorius, by which it would ſeem, that of eight pounds of food and drink, five pounds, or, according to other experiments in a colder country, from thirty to fifty-ſix ounces areperſpired, which neither add to the weight of the body, nor eſcape by any viſible excretion, except the ſaliva, ſweat, and mucus of the noſe. But the cutaneous exhalation is even much larger than this; ſince it not only throws off ſuch a proportion of the alimentary matters, but likewiſe rediſcharges what the blood acquires by inhalation (CCCCXLII.) In this, however, the different ſtates of the air, and of the body, have great influence. In warm countries, in the ſummer months, and in young active perſons, more goes off by tranſpiration, and leſs by the urine. But in cold climates, during the temperate and winter ſeaſons, in aged or inactive perſons, more goes off by the urine than by the inſenſible perſpiration. In temperate countries, making a computation throughout the whole year, ſomething more is perſpired than what paſſes off by urine; and, by collating all the experiments made in different countries, both ex-

cretions are almoſt alike. It is alſo ſomewhat affected by the difference of time after eating; and the law which ſeems to obtain, is, that the perſpiration is moſt copious at that time when the alimentary matters, being moſtly digeſted, and received into the blood, are fitted for exhalation. It is naturally diminiſhed during ſleep, even in the warmer climates; but it is increaſed by the heat of the bedclothes.

ccccxxxix. In general, a plentiful and equable perſpiration, at the ſame time that the body is ſtrong, are good ſigns of health; for exceſſive perſpiration, when conjoined with debility, is obſerved to do more miſchief than its entire ſuppreſſion, if what has been written on this ſubject is ſufficiently to be depended on. It is a ſign of health, becauſe it denotes the perviouſneſs of the veſſels diſperſed throughout the whole body, and the complete digeſtion of the aliments, of which a great part is reſolved into halitus. When it is diminiſhed, it indicates conſtriction of the ſkin, weakneſs of the heart, and imperfect digeſtion. When exceſſive, it perhaps waſtes the nervous ſpirits. This diſcharge is, by moderate exerciſe, increaſed to ſix times that of a perſon at reſt, to the extent of a pound in an hour, or even in half an hour. It is farther increaſed, if aided by ſtrong and open veſſels, by warm, watery, and cordial drinks, by food of eaſy digeſtion, by a denſe and temperate atmoſphere, and by cheerfulneſs. It is diminiſhed or ſuppreſſed by the contrary cauſes; as a denſe ſkin, a moiſt, or a cold and dry atmoſphere, reſt, an increaſed flow of urine, the ſupervention of a diarrhœa; and laſtly, nervous agitation, from a diſagreeable affection of the mind. However, the continuance of life does not depend ſo intimately on this diſcharge, which is ſo eaſily, and without bad conſequences, increaſed or diminiſhed by ſlight cauſes; and is ſo inconſiderable, in many nations, anointing their ſkins with

oil,

oil, and in many animals. When by being ſuppreſſed, it produces ſuch bad effects in fevers of a bad kind, it hurts chiefly by the putreſcent particles, which are retained by the perſpiration being ſuppreſſed.

ccccxl. The ſweat is evidently of a ſaline nature; as appears both from its taſte, and from the cryſtals which form upon the clothes of glaſs blowers; and by diſtillation, which demonſtrates its alkaline nature. Hence, by this diſcharge, the miaſmata of the moſt peſtilential diſeaſes are frequently expelled. But, in reality, ſweat is always a preternatural diſcharge, and ought never to exiſt in a healthy perſon, unleſs by violent bodily exerciſe, he have induced a temporary diſeaſe. It alſo is frequently injurious in acute diſeaſes; by waſting the water of the blood, ſo that the reſt becomes thicker, and the ſalts more acrimonious. By violent exerciſe, or the heat of the climate, the ſweat is rendered extremely fetid, and even ſanguineous; being electrical, it ſometimes is lucid.

ccccxli, The uſes of perſpiration are, to free the blood of its redundant water, of its alkaline impurities, rendered more acrid by repeated circulations; and of an extremely volatile oil, probably prepared from the ſame blood. The ſame perſpiration likewiſe qualifies and ſoftens the cuticle, and preſerves the neceſſary ſoftneſs of the papillæ.

ccccxlii. But the ſame ſkin, which has veſſels exhaling into the air, is likewiſe repleniſhed with veſſels, which abſorb thin vapours from the air, either perpetually, or at leaſt in a moderate degree of cold; in a moiſt atmoſphere; in the night time, when the body is at reſt, the mind depreſſed, and under circumſtances, contrary to thoſe mentioned above, (ccccxxxviii.) which increaſe perſpiration. Theſe veins are demonſtrated by anatomical injections, which, if thin or watery, exude through them in the ſame manner as through the arteries: moreover,

moreover, by the manifeſt operations of medicines, diffuſed in the air, or applied to the ſkin: of vapours, mercury, turpentine, ſaffron; of baths, mercurial plaſters, tobacco, coloquintida, opium, cantharides, arſenic; by the fatal effects of poiſons, abſorbed by the ſkin; as the venereal poiſon; by the living of animals, without drink, in hot but humid iſlands; by the perſpiration and urine being ſufficiently copious in ſuch ſituations, without much drink; and laſtly, by extraordinary morbid caſes, in which the quantity of urine diſcharged has far exceeded the drink taken in; in which it is probable, that the inhaling pores were more open; for that new ones were generated, is not credible. It is difficult to aſcertain its quantity; that it is very great in plants, in the night time, is proved by certain experiments.

ccccxliii. Both the exhaling and inhaling veſſels, may be contracted and relaxed by the nervous power. This appears from the effects of the paſſions of the mind; which, if lively and exhilirating, relax the exhaling veſſels, by increaſing the impulſe of the influx of blood; and by the remiſſion of the nerves; hence redneſs, moiſture, and turgeſcence of the ſkin. Thoſe paſſions which are languid and depreſſing, contract the exhaling veſſels; as appears from the dryneſs of the ſkin, produced by them; from the gooſe ſkin, by terror; and from diarrhœa, cauſed by fear. They alſo ſeem to dilate the inhaling veſſels, whence fear facilitates the action of the ſmallpox and the plague.

CHAP. XIII.

TASTE.

CCCCXLIV. THE organ of tafte differs but flightly from that of touch. It appears, by certain experiments, to be feated in the tongue chiefly; for neither does fugar, applied to any other part of the mouth, excite the leaft fenfe of tafte in the mind; nor any other fapid body, unlefs it contain fomething vehemently penetrating; in which cafe, the palate, root of the tongue, uvula, and even the œfophagus, are affected by the fapid acrimony. That fenfation, which is fometimes excited in the ftomach, œfophagus, and fauces, by the regurgitation of the aliments, feems alfo to belong to the tongue, to which the fapid vapours are applied.

CCCCXLV. Only the upper furface and lateral edges of the tongue are fitted by nature to exercife the fenfe of tafte. By the tongue we underftand a mufcular body, lodged in the mouth, obtufe, very broad in man, and divided in the middle by an obfcure fulcus. Its pofterior and lower parts are varioufly connected to the adjacent bones and mufcles; its anterior and upper parts are moveable. In that portion which conftitutes the organ of tafte, the fkin continuous with that of the face and mouth, adheres to the mufcular flefh, but is pulpy and foft, from the perpetual warmth and moifture. From this fkin arife innumerable nervous papillæ, of a more confiderable fize here than in other parts. Of thefe there are feveral kinds: the firft kind confifts of nine or ten, at the back part of the tongue, difpofed in a line on each fide of the foramen cæcum. Thefe, furrounded by a circular groove, for the moft part refemble an inverted cone, and have a deep finus in their middle; but are otherwife hard, and but indifferently adapted for tafting, although you can

can eaſily trace nerves into them. There are ſome other papillæ of the ſame kind found ſcattered before theſe upon the back of the tongue.

CCCCXLVI. Theſe degenerate into the fungiform claſs of papillæ, which are found diſtributed over the upper ſurface of the tongue, leſs and ſlenderer than the former, always becoming more pointed as they proceed forwards, till around the edges of the tongue they are crowded together, and diſpoſed in diverging lines. The third ſort of papillæ are conical. Theſe are by far the moſt numerous; are diſperſed among the former, and are ſpread copiouſly over the tongue. The moſt anterior of them in the apex of the tongue, are more inclined and fluctuate; they are moſt remarkably numerous in the edges of the tongue; there are even ſome behind the foramen cæcum. They are highly ſenſible, and conſtitute the true organ of taſte: other papillæ are intermixed, partly conical, and partly filiform; and of the conical ones ſome are larger, and others ſucceſſively ſmaller.

CCCCXLVII. Theſe papillæ, beſides numerous veſſels, are ſupplied with nerves which may be traced into the larger papillæ, and with which the tongue is more largely ſupplied than almoſt any other part. For, beſides a nerve of the eighth pair, which, with one of its principal three branches, enters deeply into the baſis of the tongue, covered by the cerato-gloſſus, near the os hyoides; there is alſo a conſiderable nerve that goes to the muſcles of the tongue, from the ninth pair; which having inoſculated with the firſt nerve of the neck, and with the large cervical ganglion, and having ſent a branch downwards, often uniting with the eighth pair, and conſtantly with the ſecond and third of the neck, and ſupplying the muſcles ariſing from the ſternum, and frequently communicating with the phrenic nerve, proceeds with the reſt of its trunk to the tongue. This communicates in the cerato-gloſſus,

rato-gloſſus, by many branches, with the fifth pair, and is chiefly ſpent upon the genio-gloſſus. Laſtly, the third branch of the fifth pair having ſent upwards or received the cord of the tympanum, and given other branches to the internal pterygoid, and biventer; to the maxillary gland, forming with theſe a ganglion; to the ſublingual gland, and croſſing with its principal trunk the cerato-gloſſus, where it is united with the ninth pair, comes to the tongue, in company with the deep ſeated artery, with which it penetrates to the tip of the tongue, where it becomes cutaneous. To this nerve, therefore, if there be any preference, the ſenſe of taſte is to be eſpecially aſcribed, which is even confirmed by morbid examples. Laſtly, the papillæ of the tongue are of a hard texture; a firm, pulpy, cellular ſubſtance uniting the arteries, veins and nerves into maſſes, of which many compoſe one large papilla.

CCCCXLVIII. The arterial and venous villi, which run between the papillæ, are for the purpoſes of exhalation and inhalation, and have nothing to do with taſte, farther than that they ſeparate from the blood, a liquor proper for diſſolving ſalts, and for keeping moiſt the papillæ, which they pour out on the back of the tongue. On the upper and back part of the tongue, are ſeated many ſimple muciferous glands, opening by one or more outlets, and of a round ſhape, formed by an hemiſpherical membrane, and the fleſhy part of the tongue. Some of theſe open into an obſcure blind cavity, of an uncertain figure, which is placed in the middle of the largeſt papillæ, (CCCCXLV.) and commonly contains ſome of them.

CCCCXLIX. The papillæ of the human tongue are covered only by a mucous, ſemipellucid membrane, which adheres cloſely to them, and ſerves them as a cuticle. But, in animals, a perforated network

receives

receives the papillæ, which enter into hollow cornuted ſheaths.

CCCCL. Under the papillæ lies the muſcular ſubſtance of the tongue, compoſed of various muſcles, but in man hardly extricable. The lower part is in a great meaſure made up of the genio-gloſſus muſcle extended outwards from the commiſſure of the chin, and diſtributed like rays upon the tongue. The upper and lateral parts are compoſed of the ſtylo-gloſſus, whoſe fibres run to the tip of the tongue. Its middle part between theſe is compoſed of the proper lingual muſcle, which ariſing from itſelf before the pharynx, and from the ſtylo-gloſſus, but deeper, proceeding forwards, is terminated there, and in the genio-gloſſus muſcle, and between that and the ſtylo-gloſſus, conſtitutes a conſiderable part of the tongue. The back part is formed by the cerato-gloſſus, of which the fibres aſcend upwards and backwards, and which is included between the ſtylo-gloſſus and lingualis, and by the chondro-gloſſus, an entirely different muſcle, which ariſes from the ſmall bones of the os hyoides, and the neareſt part of its baſis, from whence paſſing outwards, covered by lateral layers of the genio-gloſſus, and joining the ſtylo-gloſſus, it diſappears in the tongue. By the action of theſe muſcles, the whole tongue is moveable in all directions, and is capable of varying its own figure, becoming concave when elevated by the ſtylo-gloſſi, being again flattened by the cerato-gloſſi, being rendered narrower and almoſt cylindrical, by the tranſverſe fibres of the tongue; beſides which, there are other orders in the human tongue inextricable and intermixed with much tenacious fat.

CCCCLI. The arteries of the tongue are numerous. The largeſt, which is deep ſeated and ſerpentine, comes from the external carotid, and extends along the lower part to the tip of the tongue; a ſmaller ſuperficial artery, incumbent on the ſublingual gland,

gland, and inosculating with the preceding, arises either from it, or from the labial. Other small posterior arteries arise either from branches of the labial, or from the tonsillaris. The veins of the tongue are variously intricated, and difficult to describe; one, lying deep, accompanies the nerve of the ninth pair; another, superficial, accompanies the mental artery, and, inosculating with the former, forms the ranular vein; but all of them tend towards that large vein, which is a different branch of the internal jugular, from the cerebral one. They variously communicate with the adjacent tonsillary, thyroid, pharyngeal, and cutaneous plexuses; and on the back of the tongue, before the epiglottis, those of the right and left sides are interwoven with each other. I find lymphatic vessels rather in the neighbourhood of the tongue, than in the tongue itself.

CCCCLII. The papillæ of the tongue, being larger and softer than those of the skin, and perpetually moist, perform the office of touch more exquisitely than those of the skin, which are dry and small; hence the tongue suffers more acute pain: moreover, the cutaneous papillæ receive no other sensations from salts than those of moisture or pain. But the papillæ of the tongue being erected and somewhat protuberant, to perform the office of taste, are affected in such a manner by salts dissolved in water, or saliva, and applied to their summits, that the mind distinguishes certain classes of taste, as sour, sweet, rough, bitter, salt, urinous, spirituous, aromatic, pungent of various kinds, insipid, putrid, and others partly purely saline, and partly changed, and compounded by the admixture of subtile animal or vegetable oils. All very acrid salts excite pain instead of taste. Does the diversity of flavours arise from the different figures of the salts? Does this appear from the cubical figure of sea-salt, the prismatical figure of nitre, or the particu-

lar

lar configuration of vitriol, ſugar, &c.? It does not ſeem probable, for even inſipid cryſtals have their particular figures; and in ſalts, very different in taſte and other properties, the figures are too much the ſame, and again are inconſtant in the ſame ſalt, as for example, in nitre, which may by art be rendered cubical. The cauſe of taſte ſeems therefore to reſide in the internal ſtructure of the elements, not perceptible by our ſenſes.

CCCCLIII. But the nature of the covering of the papillæ, of the ſaliva, of the fluids, and of the aliments lodged in the ſtomach, have great influence on the perception of taſtes; inſomuch, that the ſame flavours do not affect all ages alike, nor all temperatures; nor even the ſame perſon, according as he may be in health, diſeaſed, or habituated to it. In general, whatever contains leſs ſalt than the ſaliva does, ſeems inſipid.

CCCCLIV. The ſpirituous parts, more eſpecially of vegetables, are received either into the papillæ themſelves, or into the abſorbing villi of the tongue; as appears from the ſpeedy renovation of ſtrength by liquors of this kind, even when they are not taken into the ſtomach.

CCCCLV. Nature deſigned the diverſity of flavours, that animals might know thoſe things moſt proper for their food: for in general, there is no aliment unhealthy, that is of an agreeable taſte; nor is any thing ill taſted that is fit for the food of man. We here take no notice of exceſs, by which the moſt healthy food may become prejudicial, or of minerals, which are not furniſhed by nature, but prepared by art. Thus nature has invited man to take the food neceſſary for his ſubſiſtence, both by the pain called hunger, and by the pleaſure ariſing from taſte. But animals, which do not learn from example and the inſtruction of others, diſtinguiſh flavours more accurately, and, admoniſhed by that teſt, abſtain cautiouſly from unhealthy

unhealthy food; and, therefore herbiverous animals eſpecially, to which a very great diverſity of aliments mixed with noxious plants are offered, are furniſhed with ſuch long papillæ, and ſo elegant a ſtructure of the tongue, for which man has leſs occaſion.

CHAP. XIV.

SMELL.

CCCCLVI. TO the ſame uſe of diſcerning prejudicial food, the ſenſe of ſmelling is ſubſervient; by which we both perceive their noxious nature, before they be taſted, which might be dangerous; and eſpecially avoid putridity in our victuals, which to us is exceedingly hurtful; and diſcover what is grateful and wholeſome; although by habit, this advantage of ſmell is more conſpicuous in animals than in man. But men who have been left to themſelves, and whoſe ſenſe of ſmell has not been corrupted by variety, have been obſerved moſt certainly to retain that ſagacious faculty in diſtinguiſhing food in an eminent degree. Finally, the powers of medicinal plants are hardly to be eſtimated better than by the ſimple teſtimonies of taſte and ſmell. Hence, in all animals the organ of ſmell is placed near the mouth; and hence the ſmell is ſtronger, and the organs larger, in thoſe animals which have to ſeek their prey at a conſiderable diſtance, or to reject deleterious plants from among their food.

CCCCLVII. The ſenſe of ſmelling is performed by means of a ſoft, pulpy, vaſcular, papillous, porous membrane, which lines the whole internal cavity of the noſtrils, and is thicker upon the ſeptum and principal cavity of the noſe, but thinner in the ſinuſes. It is plentifully ſupplied with very ſoft nerves,

nerves, the middle ones of which deſcend from the firſt pair, (CCCLVII.) through the holes of the os cribroſum to the ſeptum narium; but in ſuch a manner that it is very difficult to trace them to their extremities and into the ſeptum. Other lateral nerves come from the ſecond branch of the fifth pair and its branches, from that which croſſes the pterygoid canal, and from another which deſcends through the canals of the palate; and in the maxillary ſinus from the infra-orbital branch, from the dental branch, and from the anterior nerve of the palate. Moreover, the anterior part of the ſeptum has a twig from the ophthalmic of the firſt branch of the fifth pair.

CCCCLVIII. The noſtrils are ſupplied with very numerous arteries; from the three naſal branches of the internal maxillary, above from both the ethmoidal branches, and the frontal and naſal branches, with lateral arteries from the ſmaller ophthalmic branch of the internal carotid, and from branches of the palatine artery, and in the ſinuſes from the infra-orbital, and from the ſuperior dental one. Theſe arteries have the property of exuding blood eaſily, and in great quantity, without any leſion of conſequence. The correſpondent veins form a very large plexus upon the external pterygoid muſcle; then communicate with the ſinuſes of the dura mater; and, laſtly, meet in the external branch of the internal jugular. The arteries ſupply nouriſhment, warmth, and mucus.

CCCCLIX. The head, eſpecially in man, being of a ſpherical figure, confines the organ of ſmell within a ſmall ſpace. That it may be extended internally, the noſtrils have been made complicated and cavernous in a ſurpriſing manner. In the firſt place, the noſtrils are that multiform cavity which begins at the anterior openings of the noſe, and, extending tranſverſely backwards over the roof of the palate under the ethmoid bone, terminates at the

the cavity of the fauces. This cavity is divided by a feptum, often unequally, which is bony in the upper part, and defcends from the plate of the ethmoid; below, it is formed by the vomer, and in its forepart it confifts of a triangular cartilage, whofe furface is large and very fenfible.

CCCCLX. Moreover, the lateral furfaces of the nares are increafed by the fpiral convolutions of the offa turbinata; the uppermoft of which are the fmall fuperior and pofterior convolutions of the ethmoid bone. The middle ones belong to the fame bone, are of a long conchoid form, convex inwards, externally concave, pointed at both ends, covered all over with pits, and internally filled with fpongy cells fufpended tranfverfely, and fupported by particular eminences of the palate and maxillary bones. The loweft turbinata are fimilar to the middle ones; like them refemble in figure a limpet fhell, but longer; are for the moft part divided from the former, but fometimes conjoined by a bony plate which is moft frequently of a membranous nature. This appendix, being extended upwards in a fquare form, completes the maxillary finus.

CCCCLXI. The cavity of the noftrils is ftill further enlarged, by means of the various finufes, which are receffes or a kind of appendages to the noftrils. The uppermoft of thefe are the frontal finufes, which are inconftant and irregular, feated in the fuperciliary ridge, and fituated betwixt the anterior and pofterior plates of the frontal bone. They are not found in the fœtus, and feem to arife from the action of the corrugator and other mufcles, which draw the anterior plate outwards, and increafe the diploë into cells, in the fame manner as in the maftoid procefs. Thefe open in the upper part of the noftrils into the anterior cell of the os papyraceum. There are inftances of their being totally wanting, and growing after birth.

CCCCLXII.

ccccLxii. The fecond in order are the ethmoidal finufes; of which four or more on each fide are found in the outer part of the os cribofum, like the cells of an honey comb; above, they are completed by the cellular diploë of the os frontis, before by the os unguis, and behind by the palate and fphenoidal bone; they open into the upper part of the noftrils in a tranfverfe line, by many fmall tubes, even placed one above another. With thefe are continuous the cells in the bottom of the orbit, and thofe excavated in the os planum and maxillare are outwardly continued from them. In the third place, the large cavity of the multiform bone on each fide is alfo contiguous, and in fome meafure belongs to the ethmoid and palate bones. By the drying up of the cartilage, which is here of large extent in the fœtus, it gradually is formed in the folid bone, under the fella turcica, is capacious, either fingle or divided, and opens forwards by its aperture into the upper paffage of the noftrils.

ccccLxiii. The laft, loweft, and largeft of the finufes, which in the fœtus exifts in fome degree, but in the adult, by the attenuation of the bony laminæ, becomes very large, is chiefly excavated in the upper maxillary bone. Its opening into the noftrils is bounded by the os unguis, bone of the palate, proper lamella of the loweft os turbinatum, and by membranes, fo that it enters by a round aperture between the middle and loweft fpongy bones. But it likewife fends forth an hollow appendix, ftretching forwards under the orbits, which is formed by the os planum, unguis, and papyraceum, communicating likewife with the ethmoidal cells, and opening behind the oftium lachrymale.

ccccLxiv. The nerves of the nofe, being almoft naked, require a defence from the air, which is continually infpired and expired through the noftrils, for the purpofes of refpiration. Nature has therefore

therefore ſupplied the noſtrils, in place of a thicker cuticle, with a viſcid, bland, inſipid mucus, fluid at its firſt ſeparation, but by the air condenſing into thick dry cruſts, and more conſiſtent here than in other parts of the body. By this mucus the nerves are defended from drying and from pain. It is poured out from the very numerous ſmall arteries of the noſtrils; and is depoſited partly into numerous cylindrical ducts, and partly into round viſible cryptæ, ſcattered throughout the noſtrils. The ſame mucus exudes over the ſurface of the whole olfactory membrane, and every where anoints it. In the ſeptum, a long ſinus, common to many muciferous pores, runs forwards a conſiderable way. The mucus accumulated in the night time, in too great quantity, is expelled during the day by compreſſing the noſtrils, and forcing the breath through them; or by its dryneſs and acrimony, it irritates the very ſenſible nerves, and is then expelled by the ſneezing excited. But the ſinuſes which abound with mucus, evacuate it according to the different poſtures of the body; by ſome of them always being at liberty to diſcharge it, whether the head be erect or inclined forwards, or to the ſide; yet ſo, that generally the maxillary and ſphenoidal ſinuſes are more difficultly emptied than the reſt. Moreover, the tears deſcend through a proper duct into the noſtrils, and moiſten them, and dilute the mucus.

CCCCLXV. The extremities of the noſtrils are covered by the noſe, which is lined inwardly with a membrane of the ſame nature, and is compoſed of two bones, and uſually ſix cartilages, two of which are continuous with the middle ſeptum (CCCCLIX.) The noſe may be moved by its muſcles, ſo as to be raiſed and dilated by a muſcle common to it and the upper lip, and to be contracted by its proper depreſſor and compreſſor, and depreſſor of the ſeptum. Thus the organ of ſmell is prominent, and expoſed to the action of odours, and may be dilated

for taking in a larger quantity of air, and again be contracted, when the ſuperabundance is expelled.

CCCCLXVI. The air, therefore, filled with the very ſubtile, inviſible, pungent, oily, ſaline, and volatile effluvia, which exhale from almoſt every known body, being received into the noſtrils, by the action of reſpiration, (CCLXV.) and by a peculiar effort for drawing the air into them, carries theſe particles to the nerves, widely naked, and conſtantly ſoft. By theſe there is excited in theſe nerves a kind of ſenſation which we call ſmell, by which we diſtinguiſh the ſeveral kinds of oils and ſalts, in a manner ſomewhat indiſtinct, difficultly reducible to claſſes, difficultly recalled to the memory, nevertheleſs ſufficiently for our purpoſes. This ſenſe informs us of unwholeſome putridity, of exceſſive acrimony, and of the bland and uſeful nature of ſubſtances. And as ſalt, united with oil, is an object of taſte, and as oils, combined with ſalts, conſtitute odours, the affinity of the two ſenſes, which was neceſſary to derive utility from either, is apparent. But volatile particles chiefly are diſtinguiſhed by ſmell, and fixed ones by the taſte; perhaps becauſe the thick mucous cuticle, ſpread over the tongue, intercepts the action of the more ſubtile ſalts, which eaſily affect the ſofter and leſs covered nerves of the noſtrils. We are ignorant of the reaſons why ſome ſmells pleaſe, and others diſpleaſe; perhaps cuſtom may have ſome influence in this reſpect.

CCCCLXVII. The action of ſmells is ſtrong, but of ſhort continuance; becauſe particles in a very minute ſtate are applied to naked nerves, in the immediate vicinity of the brain. Hence the deleterious and refreſhing actions of odours, by which people are reſuſcitated from faintings, and even from drowning. Hence the violent ſneezing, excited by acrid particles, the evacuation of the bowels, by the ſmell of purgatives, and the power of antipathies.

Hence

Hence the pernicious effects of exceffive fneezing, more efpecially blindnefs, from the great fympathy of the nerves. Amongft the various parts of the noftrils, the feptum, and the offa turbinata, and their anterior portions, efpecially form the organ of fmell: fince thefe parts are multiplied in quick fcented animals, forming beautiful fpires in quadrupeds; and in fifh, being diftributed in parallel laminæ elegantly toothed.

CHAP. XV.

HEARING.

CCCCLXVIII. AS the fenfe of fmelling diftinguifhes the fmall bodies which float in the air, hearing perceives the tremors of the elaftic air itfelf. Therefore, the fenfitive organ of the ear is compofed in a different manner from that of any of the other fenfes; as it is in a great part made up, either of elaftic cartilages, or hard bones, that it may communicate with accuracy the tremors received.

CCCCLXIX. The external organ of this fenfe is the ear, or that cartilage which is connected before and behind to the bones of the temple, by ftrong cellular fubftance and proper ligaments, with fome degree of mobility, which is diminifhed by habit. This cartilage is of a compound figure; in its general fhape, oval, but divided by projecting convolutions and intermediate grooves, to which other hollows and ridges correfpond in the oppofite furface. The outer eminence, called helix, arifes above the loofe lobe, and furrounding the ear, terminates in a projecting line dividing the concha. Below it, lies the anthelix, a bifurcated eminence, forming a ridge contained within the former, and terminating in a fhort tongue called the antitragus. The remaining

part of the ear hollow before, and convex behind, growing gradually deeper, having a projecting line running through its middle, is called the concha, and is joined with the meatus auditorious, which is protected by a nearly round moveable appendix, called the tragus.

CCCCLXX. All this part of the ear is only covered by a thin ſkin, and lean cellular ſubſtance; and is repleniſhed with many ſebaceous glands, ſupplying an ointment. It is moved by certain muſcles, which generally become uſeleſs, from habit and the cuſtom of binding them, which, however, it is probable were appointed by nature to perform certain offices. The uppermoſt of theſe muſcles ariſes thin from the frontal and from the aponeuroſis of the cranium; whence it is broadly ſpread over the aponeuroſis of the temporal muſcle, and is inſerted into the anthelix, or neighbouring helix, at the anonymous cavity. The poſterior muſcles, which are two or three, or more or leſs, are more robuſt than the former, almoſt tranſverſe, and ariſing from the aponeuroſis of the cervical muſcles, and from the membranes adhering to the maſtoid proceſs, are inſerted into the convex part of the conch, and without doubt dilate it. The anterior muſcle is the leaſt; this alſo is ſpread upon the aponeuroſis of the temporal muſcle, and is inſerted almoſt tranſverſely into the origin of the helix and into the neighbouring concha. But ſmaller, ſhort muſcles, hardly diſtinguiſhable, though ſomewhat red, probably make ſome change in the ear itſelf. The tranſverſe muſcle of the ear, joining the concha with the concave back part of the anthelix, opens the ear. The antitragicus, deſcending from the root of the anthelix to the upper part of the antitragus, widens the entrance of the conch. The tragicus, which lies upon the tragus, and is almoſt ſquare, dilates the aperture; the muſculus inciſuræ majoris, lies between the middle and third cartilages of the auditory

tory paſſage, brings them nearer together, and renders the meatus itſelf more elaſtic. The remaining muſcles, the longer or larger, and the leſſer of the helix, have hardly any great uſe; perhaps they have ſome influence when we wiſh to hear weak ſounds more accurately, and tighten the organ of hearing, and render the meatus auditorious firmer by drawing together the cartilages.

ccccLXXI. With the concha is connected the meatus auditorious, of a round compreſſed figure, inclined inwards, leſſening as it proceeds, about the middle bent forwards, and for a conſiderable part bony. But, in its anterior and outer part, it is partly formed of three imperfect rings, the firſt ariſing from the tragus, the ſecond from the concha, and the third from the other two, connected with each other by intermediate muſcle, membrane, and cartilage, and finally adhering to the bone itſelf. The upper and back parts of the meatus are formed by mere membrane. This is the ſtate of it in adults; for, in the fœtus and new born infant, the meatus is wholly cartilaginous, and its oſſeous part is gradually formed.

ccccLXXII. Into this auditory paſſage are continued the cuticle and true ſkin, which are gradually extenuated and exactly ſtretched over the bone, and are therefore very ſenſible of any irritation, pleaſure or pain; and by the irritable hairs with which it is furniſhed, intimation is given of the accumulation of any ſordes, and of the entrance of inſects. In the cellular ſubſtance, which is ſomewhat indurated and reticulated, eſpecially in the membranous portion, (ccccLXXI.) there are numerous yellow round follicles, which, by ſhort ducts, depoſite into the cavity of the auditory paſſage a liquid, at firſt oily, but afterwards becoming gradually thick, bitter, and inflammable, which lines the ſenſible ſkin and membrane of the tympanum, and defends them from the air, and drives

away

away or keeps back infects; but, when accumulated in flothful or uncleanly perfons, it caufes deafnefs.

CCCCLXXIII. Into the ear the fonorous waves of the air flow, which, from the principles of mechanics, it collects. The elaftic air receives fonorous vibrations; and particularly tranfmits them, although fome other bodies alfo propagate fonorous vibrations, either alone, or at leaft in the greateft degree, if indeed water deprived of air be capable of vibrating. Hence, found is increafed in air that is condenfed, and is loft in vacuo. The air receives thefe tremors, either from fome body ftriking againft it, or from fome body againft which it rufhes, or laftly from the mutual collifion of bodies. But a body which produces found, muft vibrate and ofcillate in all, even in the leaft of its particles, fo as to form alternate arches rifing up from the former ftraight furface, and returning beyond the fame. This fpecies of curved line is called the excedens of the founding body. The tremor impels the neareft wave of air, and thus the anterior portion of air being compreffed, as foon as its elafticity overcomes the impelled tremor, rebounds and repels the air towards the founding body, where the air is now more rarefied and thin, and compreffes it. The fame portion of air, ftruck by the founding body, in like manner impels the portion of air contiguous to it, which alfo reacting in due time, repels the tremulous air backwards towards the body, and forwards to produce a new wave. Thefe ofcillations muft thus fucceed each other quickly, to render them audible, and muft not be fewer than 30 in a fecond.

CCCCLXXIV. Acute founds are, in general, emitted from bodies that are hard, brittle, and very tenfe: grave founds are connected with the contrary properties. Thofe founds in general are called acute

acute, which are produced by more frequent vibrations in a given time; and thofe obtufe, which are produced by lefs frequent vibrations. There is no limit between acute and grave founds, but what is arbitrary. Cords, or other bodies, that yield the fame number of vibrations in a given time, are faid to be in unifon. Octaves are produced when the one makes double the number of ofcillations that the other does; other proportions have different names affigned to them. The fhorter cords produce the fharpeft tones, and the reverfe, in the inverfe proportion of their lengths; they are alfo more acute as they are tenfer in the fubduplicate proportion of their tenfion, or the weights by which they are ftretched. Experiments to this purpofe are very eafily made with a monocord, or a feries of cords ftretched by weights.

CCCCLXXV. Sound, however produced, whether acute or grave, ftrong or weak, is carried through the air with a velocity equal to about 1038 Paris feet in a fecond, and that with an uniform velocity, without being diminifhed by great diftances. But a contrary wind, although much flower, retards in fome degree the progrefs of found, and takes away about $\frac{1}{22}$ of its velocity. So likewife denfity and drynefs of the air increafe found; rarefaction and moifture diminifh it. The heat of fummer augments its velocity; in Guinea, it has been tranfmitted at the rate of 1098 Parifian feet in a fecond.

CCCCLXXVI. Every found meets with particles in all adjacent bodies, even in water and mercury, in which it excites fimilar vibrations, not only in fuch as are in unifon, which yield a more evident found, but alfo in other particles, which vibrate in a different ratio. Hence every found which we hear, is a mixture of the primitive tone, produced by the vibrating body, and of the fecondary tones generated by the elaftic tremors of the furrounding bodies. The ftrength of found is increafed, if the fecondary

condary ſounds ſucceed the primary one ſo quickly, that they cannot be diſcriminated by the ear; but if ſo ſlowly as to be diſtinguiſhable by the ear, they produce an echo; but this requires an interval of ſix thirds of time, or the diſtance of 55 feet betwixt the body returning the ſound and the ear.

ccccLxxvii. Sound is reflected from hard bodies in angles equal to thoſe of its incidence. But ſound emitted into the open air, being diffuſed through an immenſe ſphere, grows weaker: when ſent through a cylinder, it retains its ſtrength, and when collected into the focus of an ellipſe, as in the ſpeaking trumpet, it is increaſed, as it iſſues from the focus of the parabola in parallel, not in diverging lines.

ccccLxxviii. Therefore the ſonorous undulations, propagated through the air, ſtrike upon our ear, placed in an elevated ſituation, and naturally inclined forwards and outwards. As that is elaſtic, they are reverberated; and by alternate reflections, they are collected into the concha, and into the meatus auditorious, where they become as much ſtronger, as the ſurface of the ear is larger than the caliber of the meatus. Through that paſſage, in ſome meaſure cylindrical, they proceed inwards undiminiſhed, and increaſed by new reſonances, excited by the percuſſion of the elaſtic cartilages and hard bones, and blended with the primitive ſound.

ccccLxxix. The internal end of the meatus auditorious is terminated by the membrana tympani; in adults it is obliquely applied, of a roundiſh figure but having an appendix above, projects inwards like a ſhield, ſo that the lower half, concave towards the meatus, projects as the boſs into the cavity of the tympanum, and the upper half is concave towards the tympanum, and convex towards the meatus. This membrane is compoſed of ſeveral plates; the firſt is white and mucous, not a perfect

fect membrane, and in the fœtus only; then the epidermis; and then the true ſkin, continuous with the membrane of the meatus, and vaſcular; the third is dry, rattling, ſhining, pellucid, and without blood-veſſels. It is formed from the perioſteum of the meatus, and of the tympanum. Some tender cellular texture intervenes between theſe. This membrane is not naturally perforated with any opening, ſo far as I have been able to diſcover, and the tranſmiſſion of ſmoke is fabulous. It is conſtantly ſtretched in the groove of the ring in which it is contained, which is proper to the fœtus, but after the birth coaleſces with the reſt of the os petroſum, ſo that there is no part of the human body more tenſe or more tremulous than this. Upon the ſurface of this membrane, and more eſpecially upon its conical cavity pointing inwards, the ſonorous waves ſtrike, after their laſt reflection in the auditory paſſage, and on account of its elaſticity, force it to vibrate.

CCCCLXXX. This membrane is ſtretched over a cavity of the os petroſum, called the tympanum; which is in general of an irregularly roundiſh figure. It is divided in its middle by a promontory, and in the adult it is increaſed backwards by the cells of the maſtoid bone, which in the fœtus are wanting. The tympanum is cellular alſo before, above and behind. It is lined with a vaſcular membrane, receiving ſmall branches from the internal carotid, from the branch of the artery of the dura mater, which paſſes through the fiſſure in the aqueduct, and from the external arteries of the tympanum, and from the ſtylo-maſtoidea. It is commonly full of mucus, poured into it from the Euſtachian tube, and is divided into a kind of cells by different membranes, which are productions of the perioſteum to the oſſicula auditus.

CCCCLXXXI. Within this cavity, the little bones of hearing are ſituated, three of them being lar-

ger,

ger, and the fourth leſs. The round head of the malleus, its upper part, is ſituted in the roof of the tympanum, from whence its long handle deſcends between the laminæ of the membrane of the tympanum, as far as its middle, accurately tied to it, with a broad extremity a little incurvated outwards. It is alſo connected with the long crus of the incus by a peculiar ligament; another membrane, near its long proceſs, faſtens the malleus. A ſhort and conical proceſs above its handle, preſſes the membrane of the tympanum outwards. From the ſame place, a proceſs, very long, compreſſed, and ſomewhat broad, but of a variable figure, extends forwards into a ſulcus of the tube. The head of the malleus is articulated with the incus by two protuberant lines, and an intervening ſulcus, all of them oblique.

ccccLxxxii. Three muſcles are commonly deſcribed, as belonging to the malleus: the firſt and largeſt, the tenſer tympani, is internal, and is lodged in a particular canal of the tube, to which it runs parallel, ariſing from a proceſs of the multiform bone between the paſſage of the cerebral carotid and the hole of the artery of the dura mater; it is inſerted by its tendon reflected downwards and outwards, around a pully, into the beginning of the handle. The ſecond muſcle ariſes from a ſulcus, connected with the ſame tube, but external to it, ſhorter than the former; and carried backwards almoſt in the ſame manner, but without being reflected, it adheres by a conſiderable extent to the longer proceſs; its muſcularity is doubted, not being remarkably different from red pulpy membrane. The third, which is ſaid to ariſe from the auditory paſſage, to enter the tympanum, through a notch in the imperfect ring, to be inſerted juſt by the ſhorter proceſs into the malleus, and to relax the membrane, has never been ſeen with ſufficient certainty, either by myſelf, or by the moſt eminent anatomiſts. The tenſor, by means of the malleus,

adapts

adapts the membrane of the tympanum for the hearing of weak ſounds; the ſecond muſcle, if it exiſt, moderates thoſe that are too powerful, by drawing the malleus from the incus, and in that way, interrupting the propagation of the ſonorous tremors. If the membrane of the tympanum be broken, or the ſmall bones diſplaced, the hearing firſt becomes dull, and afterwards perfect deafneſs enſues; that part of hearing only being left, which is propagated through the bones of the ſkull.

CCCCLXXXIII. The malleus imparts the tremors which it receives from the membrane of the tympanum, to the incus, which is a ſhort thick little bone, articulated with it behind by a broad ſurface, with two ſulci and a middle eminence. The ſhorter leg of this bone, whoſe little body is bifurcated, is notched, ſuſpended by a ligament, and is held firm in a peculiar ſulcus of bone. The other leg deſcends farther, parallel to the malleus; and, by its extremity bent inwards, is adapted to the fourth bone, which it receives, being convex on that ſide, and flat on the other, and reſts upon the ſtapes, to which it communicates its vibrations.

CCCCLXXXIV. The ſtapes, aptly ſo called from its figure, lies in an inclined poſition, with a hollow head which receives the incus, with curved crura, eſpecially the poſterior one, and with an oval baſis, but flatter below, with which it fills a hole correſponding to it, commonly called the feneſtra ovalis. The crura, which are ſulcated inwardly, are joined by a denſe membrane affixed to the ſlightly hollow baſis. The ſtapes is governed by its own muſcle, which being included in a bony papilla, ſends out a ſmall tendon, which proceeds forwards, and is inſerted under the incus into the head of the ſtapes. It ſeems to draw the ſtapes ſo that its poſterior part may enter deeper into the feneſtra ovalis, and its anterior part advance outwards. Thus the nervous pulp of the

veſtibulum

veſtibulum is compreſſed, both by the baſis of the ſtapes, and by the air of the tympanum. The whole ſeat of the ſtapes is ſeparated from the reſt of the tympanum by a peculiar membrane.

CCCCLXXXV. A ſmall roundiſh oval bone, ſlightly excavated on both ſides, is connected by one ſide with the longer leg of the incus, and by the other with the head of the ſtapes.

CCCCLXXXVI. Various canals paſs out from the cavity of the tympanum. Above the two larger bones, behind the poſterior leg of the incus, is a ſmall cell, a kind of appendix to the tympanum, of the figure of a gnomon. Behind it, the cells in the os petroſum begin above the mamillary proceſs. Below theſe, that proceſs is excavated in the adult with various cells.

CCCCLXXXVII. Beſides, a peculiar canal, proceeding forwards from the anterior extremity of the tympanum, emerges from the bones between the ſphenoid and temporal bones, and correſponds with an elliptical diverging cone, partly cartilaginous, of uncertain ſtructure, and partly membranous, which opens behind the noſtrils into the cavity of the fauces, by a very large elliptical aperture, turned inwards and forwards: it is lined with a porous membrane, full of cryptæ, continuous, and ſimilar to the membrane of the nares. This forms the Euſtachian tube, which by the action of the circumjacent muſcles, may be compreſſed, and probably a little relaxed and opened again, by the circumflex muſcle of the moveable palate. By this canal, the air, during inſpiration, enters into the tympanum to be changed, and the mucus is poured around the little bones to defend them: nor is it improbable, that the air iſſues out of this tube, when the tympanum is preſſed inwards by powerful ſounds; likewiſe, ſounds received into the mouth, are conveyed by it to the organ of hearing. In inſpiration, the air preſſes the membrane of the tympanum outwards; hence

hence the humming and dulneſs of hearing in yawning; for then the air entering in greater quantity into the tube and tympanum, reſiſts the tremors of the external air.

ccccLxxxviii. Two other paſſages lead from the tympanum to the labyrinth, or innermoſt part of the ear. The feneſtra ovalis, (ccccLxxxiv.) not covered by any membrane, leads into the veſtibulum; which is a round cavity, excavated in the very hard petrous bone, and lies near the inner part of the tympanum. In that cavity there is a ſuperior elliptical receſs, an inferior circular one, and a third reſembling a groove. There is a nervous pulp in the veſtibulum, ſeparated from its bony ſides by vapour ſurrounding it. Into this the five mouths of the three ſemicircular canals, the foramen ovale, and the paſſages of the nerves and arteries open.

ccccLxxxix. In the fœtus, the canals are formed of a diſtinct hard ſhell, which is ſurrounded with ſpongy bone; in adults, they are excavated in the exceſſively hard petrous bone, ſomething larger than ſemicircles, and have ample openings. The larger poſterior and lower of theſe is perpendicular; alſo the middle and upper one is placed perpendicularly; but the outermoſt and leaſt is horizontal. The inner mouth of the uppermoſt unites with the upper opening of the poſterior.

ccccxc. But the cochlea is ſtill more wonderful. It is ſeated in an inclined poſition in the anterior portion of the os petroſum. Into its one cavity the veſtibulum opens, and into the other the feneſtra rotunda of the tympanum, which being covered by the promontory, lies hid in the bottom of the tympanum. The cochlea itſelf is compoſed of a nucleus of bone, of a conical figure, with its apex inclined inwards; divided into tubes, which are called ſcalæ, by a middle ſulcus, which is perforated, both in its baſis, and through its whole length, by innumerable

innumerable ſmall foramina, and terminates in the middle of the ſecond ſpiral. About this nucleus are wrapt two turns and a half of a canal; which, in the fœtus, is diſtinct, and has its own ſhell; but, in the adult, is united with the adjacent bone, and diminiſhes conically from the two openings mentioned above, towards the apex of the nucleus. This canal is bilocular, and divided by a partition called lamina ſpiralis, of which the greateſt part is bony, and ariſes from the nucleus, projecting from it at right angles into the hollow canal, is ſtriated, and included on both ſides in the internal perioſteum as in a capſule. The remaining and exterior portion is membranous, which completes the diviſion of the canal: thus there are formed two diſtinct ſemicanals, called ſcalæ. The interior and poſterior of theſe begins from the feneſtra rotunda, where it is ſhut by a membrane, and is called the ſcala tympani; the other anterior one ariſes from the veſtibulum, from which it has its name. From the apex of the nucleus a third cavity originates, ſhaped like a funnel. Into this the ſpiral lamina terminates by a membranaceous extremity, but ſo that the funnel communicates with each ſcala, by one ſmall hole on each ſide, and by many with the cavity of the modiolus, which is filled with nerve.

CCCCXCI. The blood-veſſels of the outer ear come from the temporal, and proper auricular branches; thoſe of the membrane of the tympanum from the temporal, from the ſtylo-maſtoideal, or from both; thoſe of the meatus auditorius come from the ſame; thoſe of the tympanum were deſcribed (CCCCLXXX.) and the veſſels belonging to the veſtibulum, cochlea, and ſemicircular canals, are from the vertebralis and ſtylo-maſtoidealis and meningea. The induſtry of late anatomiſts has traced abſorbent veſſels of a particular kind, from the veſtibulum into the tranſverſe ſinus, from the cochlea into the cavity of the ſkull.

CCCCXCII.

CCCCXCII. It now remains that we defcribe the nerves fubfervient to the fenfe of hearing, of which the principal is that called the feventh, (CCCLVII.) This nerve enters into the internal auditory finus of the os petrofum, in the blind end of which it divides. The fmaller part of the nerve enters through the upper opening in the finus, into a canal, which is at firft tranfverfe, and afterwards reflected behind the tympanum. While it defcends there, it gives off a branch through a peculiar canal to the tympanum, which afcends betwixt the malleus and incus, goes out of the tympanum, through a fiffure behind the articulation of the lower jaw, and inferts itfelf into the nerve of the tongue, (CCCCLVII.) the reafon of which fecret communication is obfcure, but ferves to explain the fympathy between the teeth and fharp founds, and burning of the ear, &c. The reft of the nerve, efcaping by the fide of the ftyloid procefs, is diftributed on the external ear, the parotid gland, a large part of the face, and upper part of the neck, both cutaneous and mufcular; and in the face, forms numerous inofculations, both betwixt its own branches, and with thofe of the firft, fecond, and third of the fifth pair; with the eighth pair, and with the third cervical pair. To the organs of hearing, it fends either no branches, or very fmall ones. The anterior part of the outer ear receives other nerves from the third branch of the fifth pair, and the pofterior part, from the fecond and third cervicals.

CCCCXCIII. But the foft portion, which is larger, but more obfcure, arifes by very minute filaments, from the fourth ventricle of the brain itfelf, (CCCLVII.) and enters through exceeding fmall holes of the inner auditory finus, in part with from three to five branches, into the veftibulum, and in part into the fulcus of the cochlea. Thefe branches in the veftibulum form three pulpy maffes, which combine

bine to form the membrane ſuſpended in the veſtibulum, and which is continued through the whole of the ſemicircular canals. The other part, which enters the ſulcus of the cochlea, has an obſcure termination.

ccccxciv. With reſpect to the nerve which is diſtributed upon the veſtibulum and ſemicircular canals, there is no doubt that it is affected by the tremors of the external air, propagated to the ſtapes; which reach the pulp of the naked nerve, through the feneſtra ovalis. That part of the nerve, which enters the cochlea, is altogether leſs underſtood. It is probable, that ſmall branches from thence paſs through the little foramina, (ccccxc.) to the perioſteum of the cochlea, and to the membranous part of the lamina ſpiralis. Do tranſverſe nervous filaments, ſucceſſively ſhorter, paſs out from the nucleus of the cochlea, along the lamina ſpiralis? Is it the organ of hearing? Theſe are queſtions, which we are yet hardly able to reſolve from anatomy; though the example of birds and fiſhes, which hear exquiſitely without a cochlea, ſeems to negative them. However this may be, it is probable, that the ſpiral plate, full of nerves, is excited to vibration by the oſcillations of the membrane of the tympanum, which agitate the air in the cavity of the tympanum, ſo that it impinges on the membrane of the round feneſtra, which again agitates the air contained in the cochlea.

ccccxcv. It is an elegant conjecture, that ſince the lamina ſpiralis forms a true triangle, of which the apex is a very acute angle, it may be ſuppoſed to contain an infinite number of cords, ſucceſſively ſhorter, which correſpond harmonically, (cccclxxiv.) with the various acute and grave tones, ſo that they vibrate in uniſon with the greateſt number of ſounds; the longeſt cords in the baſis of the cochlea, with the graveſt ſounds; and the ſhorteſt

eſt cords neareſt the apex, with the ſharpeſt ſounds. Are ſounds perceived in the middle ſemicircular canals, ſince theſe alone are found in all claſſes of animals? Or are they perceived in theſe canals, in the cochlea, and in the membrane ſuſpended in the veſtibulum? This ſeems probable.

ccccxcvi. It appears that the audable elaſtic undulations of the air, paſs through the outer ear and auditory paſſage, to the membrane of the tympanum; for when it is injured, and not repaired, the hearing is totally deſtroyed. It ſeems to be ſtretched, for hearing weak ſounds, by the muſcles of the malleus. From this membrane, the ſound is propagated through the ſmall bones to the veſtibulum; for theſe bones being deſtroyed, the hearing is again aboliſhed. The bony ſides of the veſtibulum vibrate, and agitate the aqueous fluid ſurrounding the nervous pulp. By it, the nervous pulp ſuſpended in the veſtibulum, ſeems to be affected, and that tremor to be continued through the continuous pulp of the cochlea and ſemicircular canals. Nothing farther is known: but, by undoubted experiments, elaſtic ſonorous tremors affect the auditory nerve, through the intervention of the Euſtachian tube, of the teeth, and of all the bones of the ſkull.

ccccxcvii. The diſtinction of ſounds, without doubt, proceeds from the velocity of the tremors excited in the auditory nerve, according as they ſuceed each other more ſwiftly or ſlowly; it is not neceſſary the mind ſhould number them; it is ſufficient that the different numbers excite different changes in the mind. Does the gratefulneſs of ſounds ariſe from the number of conſonances? Does the mind, inconſciouſly, number the degrees of conſonance, and derive pleaſure from their facility and frquency? Theſe are denied by the moſt expert muſicians, who prove, that much pleaſure proceeds

from ſounds having very little concordance, and related in very difficult proportions. Why are too acute ſounds intolerable? They ſeem to ſtretch our nerves in the lamina ſpiralis to ſuch a degree, that they are even ruptured, as glaſſes are broken by acute ſounds, and the ſhrill whiſtling of canary birds almoſt deſtroys the power of hearing.

CHAP. XVI.

SIGHT.

CCCCXCVIII. HEARING is the perception of the vibrations of the air; ſight perceives thoſe of light: the organ of hearing is bony, that it may admit of reſonance; the organ of viſion chiefly conſiſts of humours, which refract: the complex nature of this organ was rendered neceſſary for the defence of parts, ſo very tender, and by the diverſity of the humours, to be contained each in its proper integuments.

CCCCXCIX. The moſt external defence of the eye is afforded by the eyebrow, which is a protuberance of the ſkin, ſuſtained by muſcles, at the bottom of the forehead, full of thick imbricated hairs, and along with the frontal muſcle, capable of being pulled down by the action of the corrugator, and orbicular muſcles, ſo as to afford a ſhade to the eye in too ſtrong a light. After the eyebrow has completed its functions, it is again raiſed by the frontal muſcle, which is inſerted into it, thin and fleſhy, immediately under the continuous ſkin, faſtened to the cellular membrane of the ſkull, which is ſhining, not very unlike an aponeuroſis, and is drawn backwards by the rectangular occipital muſcle. The depreſſion of the eyebrow denotes care, its elevation, tranquillity and ſerenity of mind. It alſo turns aſide

aſide the courſe of the ſweat, and keeps off inſects from the eye.

D. The eyelids furniſh a nearer protection to the eye. Theſe are folds of the ſkin, proceeding from that of the face, extenuated, lengthened out into an edge, as if divided, reflected upon itſelf, and retracing the courſe of the former lamina, from which it is ſeparated by ſome cellular ſubſtance; then having become membranous, vaſcular, and therefore red, and thin, it is carried over the ball of the eye, under the denomination of conjunctiva tunica, and covers the anterior portion of the ſclerotica, and finally the cornea. The epidermis accompanies it in its whole courſe, even where it adheres to the cornea. The upper eyelid is larger, and more moveable: the lower is ſmaller; and rather paſſive, than moved by any power of its own. The nerves, which give ſenſibility to the eyelids, are numerous, from the firſt and ſecond branches of the fifth pair, and from the portio dura of the ſeventh; they abound with arteries from the ophthalmics, temporals, branches of the internal maxillaries, infra orbitals, and facials.

DI. That the eyelids may ſhut together more exactly, each of them has a cartilaginous arch, called tarſus, upon that margin which touches the other. It is ſlender, of a lunar figure, extenuated outwards, and ſtretches the eyelid, preventing the formation of folds while it is elevated or depreſſed. The elevation of the upper eyelid is performed by a peculiar muſcle, ariſing from the involucrum of the optic nerve gradually ſpreading, and continued by its expanſion to the tarſus. This is conſiderably aſſiſted in its action by the frontalis, which is variouſly connected with the orbicularis, and draws it upwards. The upper eyelid is depreſſed by the orbicularis, as it is called; a broad muſcle, both widely expanded around the orbit, and contained in the eyelids, carried as far as both angles of the

eye, and having, as fixed points, the ligament adhering to the proceſs of the maxillary bone, and ſome fibres inſerted into the frontal and upper jaw bone. The ſame muſcle elevates the lower eyelid, and covers the eye in ſuch a manner that no duſt or light can enter it during ſleep. The lower eyelid is depreſſed by two bundles of fibres, inſerted into the upper lip.

DII. Finally, that the tumid margins of the eyelids may not ſhut too cloſely, they are provided with eyelaſhes, or fringes of hair ſpreading outwards, proceeding in many rows from the edges of the eyelids, which, by decuſſating each other, increaſe the ſhade and obſcurity. Theſe are of uſe in more diſtinct viſion, by excluding the extraneous rays, when we require a diſtinct repreſentation of any object.

DIII. The eyelids are prevented from hurting each other by the ſebaceous glands of Meibomius, conſiſting of thirty or more follicles in each eyelid, which are ſimple, bifid or trifid; placed in general according to the length of the lid, and compoſed of peculiar blind roundiſh cavities, which unite into one larger ſerpentine duct, of which the orifice is in the margin of the eyelid itſelf. Theſe diſcharge a ſoft unctuous liniment, which mixes and waſhes off with the tears.

DIV. But the perpetual attrition cauſed by the eyelids aſcending and deſcending againſt the globe of the eye is prevented, the delicacy of the cornea is preſerved, and any inſects or other irritating ſubſtances which may have got into the eye, are waſhed away by the tears; a ſaline, pellucid, and evaporable liquor, which never ceaſes to be poured over the anterior ſurface of the eye, but never runs over the cheeks, unleſs accumulated from ſome cauſe. This liquor is exhaled partly from the arteries of the conjunctiva, as we ſee from an imitation of nature by injecting water; and in part it is believed

believed to proceed from a gland ſeated in a hollow receſs of the os frontis, ſomewhat hard, and of the conglomerate kind: divided into many lobes, intermixed with fat, and ſupplied with many blood-veſſels from the ophthalmics and internal maxillaries; and pervaded by many nerves ariſing from a peculiar branch of the firſt trunk of the fifth pair.

DV. From this lachrymal gland, ſix or more viſible ducts deſcend, which open on the inner ſide of the conjunctiva of the eyelid. In man theſe ducts have been lately diſcovered by credible authors. The ſecretion of the tears is increaſed by the repeated contractions of the orbicular muſcle, either from irritation, or ſome depreſſing paſſion, by which means the tears are conveyed over the whole eye, and the ſurface of the conjunctiva is waſhed.

DVI. After the tears have performed their office, ſome part of them being evaporated by the air, the reſt, that they may not prove injurious by their accumulation, are propelled by the orbicular muſcle, towards its origin next the noſe, and to the innermoſt part of the commiſſure of the eyelids; which from not having any tarſus, does not meet exactly together. There a caruncle, full of ſebaceous, hairy follicles, oblong, and conical outwards, interpoſes itſelf between the eyelids, and prevents them from meeting, and anoints with its liniment thoſe parts of the eyelids which have no Meibomian ducts. Before it, a ſmall third eyelid deſcends perpendicularly, and joins the true eyelids; it is larger in beaſts. At the beginning of this ſpace interpoſed between the eyelids, in which the tears are collected, in each margin a little papilla projects, having one orifice, ſurrounded by callous cellular ſubſtance, and perpetually open, unleſs when convulſively cloſed. This orifice, which is called the punctum lachrymale, abſorbs the tears from the ſinus in which they are collected, partly by attraction, and partly by the impulſe of the orbicular muſcle. If

theſe

theſe points are obſtructed, the tears run over and excoriate the cheek.

DVII. From each point, a peculiar duct, much wider, thin, and included in the ſkin, proceeds, the one downwards above the caruncle, and the other more tranſverſely inwards, and under it; which approach each other, and are inſerted by two mouths into the lachrymal ſac, not quite at the top; which name is given to a cavity formed in the groove of the os unguis and upper jaw, lined firſt with a hard cellular, and as it were aponeurotic membrane; then by another, red and pulpy, continued from the membrane of the nares, pervious to the exhaling moiſture, and ſomewhat of an oval figure. From this veſicle the naſal duct deſcends a little backwards into the nares, and opens by an obliquely oblong aperture, covered by the lower os ſpongioſum, into their loweſt meatus. Through this the ſuperfluous tears deſcend into the noſe, which they in part moiſten, (CCCCLXIV.) A muſcle is by ſome aſcribed to this ſac; but it is not yet ſufficiently aſcertained.

DVIII. The eye, of a globular ſhape, compreſſed before, though not always in the ſame manner, longer from the brain to the cornea than from the right ſide to the left, is ſituated in the orbit, which is an oſſeous cavity, almoſt conical, compoſed of ſeven bones, interrupted in the back and outer ſides by larger fiſſures, and widening forwards, and by which it is defended on all ſides. But as this is larger than the eye, it is filled by much very ſoft fat, ſurrounding the globe of the eye, and allowing it free motion.

DIX. The eye begins from a nerve, by the expanſion of whoſe coats thoſe of the eye are formed. Its origin we have already deſcribed, (CCCLVII.) Having paſſed acroſs the crus of the brain, it joins with its fellow from the other ſide, and coheres with it for a conſiderable way, by much medullary ſubſtance; yet ſo that the right goes to the right eye, and the left to the left, though not without

ſome

ſome reciprocal intermixture of medulla. The nerve then enters the orbit, a little inflected, and of a round form, ſomewhat compreſſed; and is inſerted, not into the middle of the globe of the eye, but a little nearer to the noſe.

DX. The nerve having reached the eye, the inner plate of its dura mater, which it received in the opening of the ſphenoidal bone, is detached: or having become thicker, is extended around the eye, as its firſt coat, called the ſclerotic, or adheres to the ſclerotic, which perfectly reſembles it, and always ariſes from it. The other plate of the dura mater, the external, recedes and forms the perioſteum of the orbit: the pia mater, which is in this nerve very diſtinct and full of veſſels, having become entirely dark coloured and thin, lines the inſide of the ſclerotic. The remaining medullary central part of the nerve, continued from the brain, but divided by cellular plates, contracts into a depreſſed white conical papilla; which entering through the holes in the white circle of the choroid coat, and again expanding, produces the moſt internal membrane of the eye, the retina.

DXI. The ſclerotica is in general white, furniſhed with few veſſels, tough and compact, reſembling the nature of ſkin, of a figure very nearly globular, but compreſſed before, and is thicker at the back part. Before this coat, which is perforated by circular holes in its forepart, is placed, and obliquely connected with it, a more convex portion of a ſphere; pellucid, compoſed of many plates, whoſe veſſels are filled with pellucid water, and are difficult of demonſtration, inſenſible, and almoſt circular, circular towards the noſe, and oval towards the temples: it is termed the cornea, and through it the light paſſes into the inſide of the eye. It readily imbibes and exudes water. Before the anterior and flatter part of the ſclerotica, and before the cornea, the conjunctiva is detached from each of the

the eyelids, and is joined to the ſclerotica by proper cellular ſubſtance, which may be inflated, (D.) and is repleniſhed, partly with red veſſels, and partly with their pellucid continuations.

DXII. The origin of the choroid coat, is from the circumference of the white cellular circle, terminating the ſubſtance of the optic nerve, and through whoſe numerous foramina, and from which the retina and arteria centralis retinæ proceeds. At that place the choroides adheres to the ſclerotic, and to the circle above deſcribed. Then it is expanded concentrically, within the ſclerotic, with which it is united, perhaps by ſome cellular ſubſtance, and by many veſſels, which come from it to the choroides. Outwardly it is of a brown colour, but inwardly of a deep ruſſet or almoſt black, and at the ſame time villous; the two ſurfaces are ſeparable by maceration; and the innermoſt may be diſtinguiſhed by the name of Ruyſch; but it grows white through age. When it has reached the beginning of the pellucid cornea, it there becomes cloſely connected with the ſclerotica, by much cellular ſubſtance, having the appearance of a white circle, called orbiculus ciliaris, and then turns off in another direction; namely, the coat, which was before ſpherically expanded, is now ſtretched under the arch of the cornea, in the form of a circle, a little convex forwards, and incomplete, having in its centre a circular foramen called the pupil, which is ſeated nearer to the noſe, and is larger towards the temple. The anterior part of this ring is called the iris; and the back part, ſeparable from the former in the human body, by maceration, in ſome animals even by the knife, is, from the black pigment with which it is covered, called the uvea. On the anterior ſurface of the iris appear numerous radiated and branching ſtreaks, of various colours in different people, and entirely covered with flocculi. Theſe terminate

on

on this ſide of the pupil in a ſerrated circle, from which other ſimilar ſtreaks extend, even to the edge of the iris. They are ſerpentine when the pupil is dilated, and ſtraight when it is contracted. On the poſterior ſurface of the uvea is much black pigment; which being waſhed off, ſtraight radiated ſtreaks appear, extending to the pupil, and not flocculent. Orbicular fibres, concentrical with the pupil, I have not been able to obſerve, either with the naked eye, or with the microſcope, even in the ox; but only in the uvea, an internal circle diſtinguiſhed by obſcurer rays, and leſs villous. In the human fœtus, the pupil is ſhut up, and the iris being continued, makes a complete circle. That part of it which extends acroſs the pupil is of a vaſcular texture.

DXIII. Though the iris has little ſenſibility, and is not endowed with any mechanical irritability; yet during life, in man, quadrupeds, and birds, the pupil is contracted by every greater degree of light, and is dilated by every ſmaller one; hence it is alſo rendered broader for viewing diſtant objects, and narrower for viewing ſuch as are near. The cauſe of this dilatation ſeems to be a remiſſion of the powers reſiſting the aqueous humour; as proved by the dilatation of the pupil, from debility, ſyncope and death. The contraction is leſs underſtood, and perhaps only depends on the ſtronger afflux of humours into the colourleſs veſſels of the iris, by which theſe veſſels are extended; and, at the ſame time, the iris is rendered longer, and ſhuts up the greater part of the pupil: ſo that this motion has ſomething in common with inflammation, as agreeing in their cauſe. In young people, the pupil is more evidently moved and contracted; as the eye gradually grows callous in old people, it becomes almoſt immoveable. In an animal twenty-three hours after death, I have ſeen the iris extended by heat ſo as to ſhut the pupil.

DXIV. Behind the uvea, from the ſame circle in which the choroides unites with the ſclerotica, more externally than the cornea, thick ſtriæ, elegantly plaited, ariſing from the choroides, white, with parallel veſſels running under them, with plumous, pendulous extremities, joined to the looſe and thin retina, and every where covered with a good deal of black pigment, depart, in the form of a perforated ring, inwards from the tunica choroidea, and proceed forwards behind the ciliary circle, and reſt upon the vitreous humour; and, laſtly, upon the capſule of the cryſtalline lens, but do not adhere to them. They are denominated the ciliary ligaments. The origin of the pigment is not known; nor have the ſecreting glands, which ſome have ſuppoſed, been found. Among its uſes, one ſeems to be, to keep the cryſtalline lens firm. In infants, this ſame mucus, behind the ciliary proceſſes, expreſſes the figure of a radiated flower.

DXV. The retina, which is a true continuation of the medulla of the optic nerve, and therefore very tender, mucous, and evaporable, is expanded within the choroides into a ſimilar ſphere, concentric with it; and immediately incloſes the vitreous humour. But when the retina has reached the ciliary proceſſes, it follows their courſe, ſupporting their arteries and ſtriæ, and proceeds to the cryſtalline lens, adhering to and covering its capſule, if the obſervations of ſome other anatomiſts, as well as my own are to be relied on; for in quadrupeds this termination of it is not perfectly certain, although in birds the internal lamina of the retina, covered with the ciliary body, is evidently continued to the cryſtalline lens; to the circumference of which it alſo adheres in man. The fabric of the retina is ſuch, that externally its ſoft and medullary globules form a thick and pulpy membrane, within which radiated fibres proceeding from the lamina cribroſa, and continued forwards, conſtitute a thinner

a thinner involucrum, very readily obferved in fifhes, and alfo in fome birds and quadrupeds, but not in man. Arterial and venous veffels with red trunks, form a net in the internal furface of the retina, which when accurately filled with coloured water compofe a membrane.

DXVI. Thefe coats, refembling the coats of a bulbous root, are fupported, and the fpherical figure of the eye is preferved by its humours: of which one is a folid, another a foft body, and a third truly a liquor. Firft, then, the concave furface of the retina is every where filled by the principal or vitreous humour, of which the ftructure confifts of a peculiar thin, pellucid, cellular membrane, in whofe cellular intervals is contained a very pellucid liquid, very rarely altering even in old age, completely evaporable by heat, nearly allied to the aqueous humour, and fomewhat denfer than water. Its veffels, which are moft manifeft in fifh, lie in the back part, moft beautifully radiated from the central trunk of the retina, embracing the convexity of the vitreous humour; and inferted into a circle formed not far from the lens by other arteries coming from the choroides, and which I have feen in the fheep. The vitreous membrane, which is tender confidering its body, adheres to the lens in two places, before and behind; fo that a hollow fpace is intercepted in the middle between the two infertions, around the cryftalline lens. This fpace is divided in different places by fome fibres. On its anterior furface the ftriæ of the ciliary body imprint their marks.

DXVII. But, in the forepart of the vitreous body, behind the uvea, there is an orbicular depreffion of confiderable depth, into the cavity of which the cryftalline lens, (alfo, though improperly, ranked amongft the humours,) is received. The figure of this lens, refembling frozen jelly, is compofed of

two

two elliptical convex ſegments, the anterior of which is flatter, and the poſterior more gibbous. It is conſtructed of concentric laminæ, connected by cellular fibres, which themſelves are compoſed of fibres elegantly diſpoſed through fine cellular membrane. Betwixt the plates of the cryſtalline lens, is alſo contained a pellucid liquor, but which, in old age, naturally acquires a yellow colour. The innermoſt ſcales are more cloſely compacted; and form as it were a harder nucleus; externally it adheres ſo very looſely to the capſule, that when that is broken, it very readily ſprings out; and ſome even ſay, that a little water is effuſed around it. It is ſupplied with an artery from the retina, which perforates the middle of the vitreous humour, and enters behind; for veſſels have not yet been diſcovered on the anterior ſurface. The whole lens is contained in a ſtrong, thick, elaſtic capſule of a pellucid membrane, more firm in the forepart, and which is lined poſteriorly by the vitreous tunic.

DXVIII. Laſtly, the aqueous humour, which is extremely pellucid and fluid, and which is renewed again if it be let out, ſwims in the ſmall triangular curvilinear ſpace betwixt the uvea and cryſtalline lens, and in that larger ſegment of a hollow ſphere which lies betwixt the iris and the cornea. This humour ſeems to exhale from the ſmall arteries of the iris, uvea, and ciliary proceſſes; being again abſorbed by the correſponding veins, while ſome portion of it is abſorbed by and exhaled through the cornea. This humour alſo moiſtens the uvea and capſule of the lens. About the beginning of the preſent century, the ſpaces filled with this liquor were called the chambers of the eye; that between the cornea and iris the anterior one, and that ſmall one between the ſurface of the cryſtalline lens and the uvea the poſterior.

DXIX.

DXIX. The eye, thus conſtructed, is provided with muſcles externally inſerted into it, by which it is governed. Namely, into the circle of the ſclerotica, which is contiguous to the cornea, are inſerted four ſtraight muſcles, ariſing almoſt in one circle from the dura mater of the optic nerve; where, departing from the nerve, it coheres with the perioſteum of the orbit, and proceeding forwards with their bellies round the bulb of the eye, they terminate again by their aponeuroſes, meeting together in another circle. Of theſe, the elevator is the leaſt, and the abductor rather the longeſt. The office of each of theſe muſcles appears very plainly; ſince, being bent round the convex bulb of the eye, as about a pulley, they muſt, of courſe, elevate, depreſs, or turn the eye either to the noſe or to the temples. Moreover, two of them acting together may move the eye diagonally; as upwards and outwards, upwards and inwards, &c. Laſtly, when all the four ſtraight muſcles contract together, there is ſcarcely a doubt that they draw back the whole eye within the head towards their origin, and thus bring the cryſtalline lens nearer to the retina.

DXX. But the fabric of the two oblique muſcles of the eye is more compound. The upper of theſe, ariſing together with the recti, is long and ſlender, aſcending forwards to a notch in the os frontis, which is completed into a hole by a double ligament, which on each ſide ſuſtains a cartilage, excavated in the middle, and almoſt quadrangular. Through this canal paſſes the tendon of the obliquus, which being reflected backwards and outwards, included in a capſule of its own, is inſerted into the globe of the eye behind the ſtraight muſcles. This draws the globe forwards, as if out of the orbit, and inwards, and turns the pupil inwards and downwards. The other, the obliquus minor from the ſinus of the lachrymal foramen in the

the upper jaw, afcends immediately outwards from the os unguis round the globe of the eye, and is inferted by its tendon into the fclerotica behind the external rectus : whence it appears to turn the point of its infertion into the eye downwards and outwards ; and, therefore, the oppofite pupil upwards and inwards.

DXXI. But there are other minute mufcular motions performed in the eye, which prefuppofe a knowledge of its nerves. Of the optic nerve we have already treated (DIX. DX.) The fourth pair goes only to the larger oblique mufcle, and the fixth pair to the rectus externus. The third and fifth pair produce the principal nerves in the eye ; the firft or ophthalmic branch of the fifth fends off a nerve at its entrance into the orbit, to the eyelid and lachrymal gland, which joins with the fecond branch of the fifth pair, and with the temporal branch of the third of the fifth pair. On entering the orbit, its trunk divides into two. The upper branch, larger and bifid, is expended on the forehead and eyelids : but the lower, penetrating inwards above the optic nerve, fends off a long flender filament at the outer part of that nerve, which, joining with another filament of the third pair forms the ophthalmic ganglion, and fends off one or two ciliary nerves. Finally, after having given off the recurrent nerve of the nofe (CCCCLVII.) it is then fpent upon different parts in the internal angle of the eye.

DXXII. But the third pair is of moft importance. After giving off a branch upwards to the ftraight mufcles of the eye, and to the eyelids, it proceeds with its trunk under the optic nerve, and at the fame time fends out three branches to the inferior, obliquus minor and internus ; after this, or before, from its trunk, or fometimes from the branch of the obliquus minor, it fends off another fhort nerve, much thicker than the root from the fifth, (DXXI.)

(DXXI.) which, under the abductor mufcle upon the optic nerve, forms the ophthalmic ganglion, which is oval and conftant, and fometimes arifes from the third alone. From that ganglion, and fometimes from the trunk of the third or fifth, four or five ciliary nerves playing around the optic nerve in a flexuous courfe, go to the globe of the eye, perforate the fclerotica almoft in its middle, in company with its longer fmall arteries or veins, run ftraight forwards along the choroides, and vifibly proceed to the iris, and feemingly to the ciliary proceffes. Other very fmall nerves, originating from the fame ganglion, remain in the tunica fclerotica.

DXXIII. The motion of the ciliary proceffes is obfcure and difficult of demonftration, (DXIV.) lying incumbent upon the furrows of the vitreous membrane, by their action they are believed to prefs back that body, fo as to bring the lens forwards, and remove it farther from the retina. But I have never feen, in all the animals I have diffected, any thing like a mufcle in this ciliary body, but only a membrane which fupports fmall veffels. The fphincter of the pupil and conftrictor of the cornea, mentioned by fome writers of eminence, and the moving fibres, which others have imagined proper to the cryftalline lens, are not confirmed by anatomy, nor are they confiftent with the conftant hardnefs of the lens and cornea in moft animals.

DXXIV. The hiftory of the eye alfo comprehends its veffels, which have a moft beautiful fabric. All thofe which belong properly to the eye itfelf come from the ophthalmic artery, a branch of the internal carotid, (CCCXVI.) This, creeping under the optic nerve, fends off, as principal branches, the upper ciliary, one or more inferior ciliaries; the lachrymalis, from whence the nafalis recurrens pofterior, and internal part of the arch of the tarfus; afterwards the mufcularis inferior, the nafalis re-

currens,

currens, anterior and posterior, the musculares superiores, and the palpebralis, which, with the former branch, forms the arch of the tarsus. Lastly, it goes to the face, nose and adjacent parts. But the ophthalmic branches, belonging to the inner parts of the eye, are called the ciliaries; which, arising from the trunks now mentioned, and playing around the optic nerve, in four or more branches, in a serpentine course, partly close by the entrance of the optic nerve, go to the choroides with forty or more branches, and make upon its external surface, ramifications divided at acute angles, which proceed forwards to the circle of the uvea.

DXXV. But most of the small arteries of the tunica choroides gradually incline towards the interior parts of the eye; and, being covered with a kind of cellular down, go to the ciliary processes, along each of which two small arteries run, giving off on every side, vascular flocculi, and inosculating at their apex.

DXXVI. Other small arteries also, likewise arising from the ciliary ones, but few in number, most commonly two, go to the place, from which the uvea originates. There, spreading in various directions, they surround the root of the uvea with their branches, and join to form a circle, into which the anterior ciliaries inosculate; which are small arteries arising from the muscular branches of the ophthalmic; and are inserted into the circle generally by twelve small trunks, near the origin of the cornea. From that circle, and likewise from the above mentioned anterior ciliary arteries, without the intervention of the circle, straight, branched vessels, are distributed, both on the iris, and on the uvea; the former full of a blue or dark coloured fluid; and the latter naturally white, but covered with a good deal of a black paint. In the uvea, at some distance from the pupil, they frequently form an imperfect circle.

DXXVII.

DXXVII. But from the ſame ophthalmic artery, from its trunk, or from the lachrymal branch, or from one of the ciliaries, one or more branches enter into the optic nerve; the principal, the central artery of the retina, penetrates into the medulla of the nerve, and paſſing through the apex of the papilla, (DX.) enters the centre of the retina; from thence it ſpreads every way through the retina itſelf, by ſo many branches, when traced by a ſkilful anatomiſt, that that vaſcular network has been taken for a peculiar membrane. Sometimes a ſmall branch goes along the centre of the nerve to the retina, and is in like manner ramified through it. From comparative anatomy, it is certain, that from theſe branches the vaſcular branches of the vitreous tunic are produced, as well as the poſterior artery of the lens. The moſt internal of theſe arteries, is the celebrated porus opticus of the ancients.

DXXVIII. The veins of the eye, in general, ariſe from the ophthalmic vein, which on the one ſide comes from the facial vein, entering the orbit; and on the other, is inſerted into the cavernous ſinus. The internal veins of the eye perforate the middle of the ſclerotica, with fewer and larger trunks than the arteries, and form larger and more anterior reticulations, of a roundiſh figure, which commonly occupy the middle of the tunica choroides: ſome, which are long, are continued to the origin of the uvea: others anterior, ſimilar to the arteries; and another, the centralis nervi optici, correſponding with the artery, goes to the retina. The pellucid veſſels do not differ from the ſanguiferous. Lymphatic veſſels are ſaid to have been ſeen in the retina; but the obſervation has not been ſufficiently repeated.

DXXIX. So far with reſpect to the anatomy; but the action of the eye is entirely elucidated by phyſical experiments, from which it has been aſcertained, in the moſt incontrovertible manner, except

a few doubtful points. Light is the ſame matter with heat, or very nearly the ſame, poſſeſſing extreme fluidity and ſubtilty, penetrating through all bodies, very rigid, not exhauſted by any diſtance of its paſſage, and moving with exceſſive velocity, ſo as to arrive at the earth from the ſun in eight minutes and thirteen ſeconds. Light in our planet proceeds either from the ſun, which ſeems to have the power of arranging in ſtraight lines, the matter of light, otherwiſe confuſedly ſcattered; or from ſome other lucid point. From it, as from a centre, the light is diſtributed like rays, to all parts of the ſphere, ſo as to fall upon the ſurfaces of all bodies; from whence again it is reflected, and impinges on the eye, at angles equal to the angle of incidence, and renders the bodies, from which it comes, coloured and viſible.

DXXX. It is aſcertained, from experiments, that light is compoſed of rays in right lines, almoſt without any phyſical breadth; and yet, each of which may be ſeparated into ſeven more minute, permanent and immutable rays. The known properties of theſe rays are, that all of them, conjoined together, conſtitute a white beam; but when refracted, and ſeparated by the minute ſurfaces of bodies, they are ſubdivided into red rays, which are the moſt conſtant, hard, and leaſt refrangible; and afterwards into orange, yellow, green, blue, indigo, and violet; which are always weaker and more refrangible, as they are farther diſtant in order from the red rays. Shade ariſes from a deficiency of reflected rays. Colours are compounded of ſhade united with various rays.

DXXXI. The peculiar colours of bodies ariſe from the minute ſurfaces of their ſolid particles, by which their pores are limited, which refract the rays of light, according to the difference of their thickneſs, reflecting one kind of rays moſt copiouſly, and in a great meaſure ſuffocating by repeated internal refractions, the others admitted into their ſubſtance: ſo that the

the thickeſt and denſeſt particles reflect a white colour; the next red; and the thinneſt violet. Bodies are opaque, which retain all the rays, and tranſmit none, from the largeneſs of their pores, to the ſides of which the light is attracted; and which are filled with ſome matter that has a power of refraction, different from that of the particles of the body. Theſe principles we embrace, till a new theory, which aſcribes the diverſity of colours to vibrations of different celerities, ſhall be better eſtabliſhed; for it is not our buſineſs to aſcertain theſe matters.

DXXXII. Theſe rays, when they fall obliquely upon liquors of various denſities, in paſſing through them, variouſly recede from, or incline towards the perpendicular: this is called refraction. In general, the denſer the medium, the more are the rays bent towards the perpendicular; excepting only inflammable liquors, which, by a peculiar property, attract the rays more to the perpendicular, than in proportion to their denſity. The proportions of the angles of incidence to thoſe of refraction, are conſtant; ſo that the ſine of the angle of refraction of rays paſſing from air into water, is to the ſine of the angle of incidence, as 3 to 4: and of rays, paſſing from air into glaſs, the ſine of the incidence is to that of refraction, as 17 to 11; and from water into glaſs, as 51 to 44.

DXXXIII. Rays, which come through the air with but little divergency, as thoſe of the ſun on account of its immenſe diſtance; or as, in general, any rays that come from a diſtance of above 100 feet, when they fall upon a body, ſpherically convex, and denſer than the air, at a large angle, as at 48½ degrees, are reflected, and do not penetrate it. If the angles are ſmaller, they penetrate the refracting medium, and are refracted in it, ſo as to meet together in one point, which is called their focus. This point lies in the axis, or in the ray, falling

perpendicularly on the surface, and therefore not inflected; and in a spherical globule of water, the focus of rays coming from the atmosphere, is at the distance of one semidiameter from the sphere; and in a sphere of glass, a fourth part of the diameter, and in a convex lens of glass, that is, a part of a sphere not less than thirty degrees, and equally convex, it is also one semidiameter; but so that the rays meet, not in a point, but in a little circle.

DXXXIV. Therefore the rays of light, whether direct or reflected, fall in such a manner upon the cornea of the eye, as to form a very acute cone, from the lucid point to the surface of the membrane: the basis of which is the surface of the cornea, and the apex the radiant point; yet so, that the rays of the cone may be considered parallel, without any sensible error. Of these rays, all those which fall upon the cornea at a greater angle than forty degrees, are reflected from the cornea without penetrating its surface. Others which enter the cornea, but still at large angles, fall in betwixt the uvea and sides of the crystalline lens, and are suffocated in the black paint that lines the uvea, (DXII.) and the ciliary processes, (DXIV.) and those rays only fall upon the surface of the lens, which enter the cornea at small angles, not much distant from the perpendicular, or at about twenty-eight degrees. By this means, all those rays are excluded, which the refracting power of the humours in the eye could not have been able to collect into one point of the retina; and which, therefore, would have painted the image on the retina too broad and confused.

DXXXV. Those rays, therefore, coming from the air, which is so thin, and passing through the cornea, which is the segment of a sphere, thick, denser than water, and therefore almost a fourth part more refracting, are remarkably inclined towards the perpendicular. By the aqueous humour, which is

small

ſmall in quantity, and almoſt like water, but rather lighter, they are not altered, and fall upon the ſurface of the tranſparent lens, before they have formed a focus, becauſe of its nearneſs, nearly parallel, or rather converging; becauſe their divergency was abundantly corrected by the refracting power of the cornea. Moreover, the cornea being convex, and more prominent than the hemiſphere of the ſclerotica, receives and collects a greater number of rays than if its ſurface were flatter, and therefore ſmaller.

DXXXVI. That the refracting power of the cryſtalline lens, exceeds that of water, may be underſtood from its hardneſs and weight, although we have no ſufficiently certain meaſure. In this lens, therefore, and more eſpecially in its poſterior very convex ſurface, the rays converge very much, and paſs thence into the vitreous body.

DXXXVIII. This ſubſtance is denſer than water, ſince it ſinks in it; but rarer than the cryſtalline lens; bends the rays a little more gently towards the perpendicular, till at length the rays, coming from a point of diſtinct viſion, are concentrated into the ſmalleſt poſſible point of the retina, where they paint an image of the object from which they come; but inverted, on account of the neceſſary decuſſations. The manner in which the images of objects are thus painted, may be ſeen in an artificial eye, or in a natural eye, when the back part of the ſclerotica is removed. But the image is painted on the outer ſide of the entrance of the optic nerve, at the termination of the axis of viſion, which is not limited to a mere point, but has ſome breadth; ſince we ſee many objects at once, whoſe images muſt be repreſented in different points. Viſion is there moſt diſtinct, becauſe the rays arrive thither nearly perpendicular. But frequently it does not fall on the ſame place in both eyes of the ſame individual. When the lens is deſtroyed, the

the vitreous humour alone collects the rays, though less powerfully.

DXXXIX. Is it entirely false that the object is painted on the retina? Is the picture represented on the choroides? Is this new opinion confirmed by the experiment, by which it appears, that the place where the optic nerve enters is insensible? and which is thus explained, that there is in that place no choroides but only the bare retina, and that therefore, it does not possess vision. But this is repugnant to a very well known observation, that the retina is a most sensible nervous medulla; and that the choroides almost entirely consists of a few small nerves, and of vessels which are most certainly blind. This is likewise contradicted by the very great variety of the choroides in animals; by the equally great uniformity of the retina; and by the black spots, which, even in man, obscure the exterior surface of the retina. But, by this experiment, we perceive the reason why the optic nerve is not inserted into the axis of the eye, but towards one side. For thus, except only in the single case, where an impediment is situated in the point of intersection of lines drawn through the centre of the optic nerves, the one eye sees and assists that whose blind portion is directed to the object.

DXL. But since the necessary functions of human life require that a distinct object be painted upon the retina, not only by the rays which come from one certain distance, but likewise that rays which come from various and very different situations, more or less distant, should excite a distinct idea of the object from which they come: therefore, it is believed, that the necessary change is produced in the eye by proper means. Some celebrated anatomists have supposed the lens moveable by the powers before mentioned, (DXIX. DXXIII.) They assert this art of changing the eye is learned by experi-

ence,

ence, and is not poſſeſſed by thoſe on whom the operation of couching the cataract has been lately performed. Alſo in an artificial eye, the advantages and neceſſity of this motion, it is ſaid, may be plainly perceived. Therefore, too great a divergency of the rays, as in thoſe which come from objects very cloſe to the eye, is corrected by the removal of the lens farther from the retina, by which means the focus, which is more diſtant, on account of the divergence of the rays, falls upon the retina itſelf, which would otherwiſe have fallen behind the retina; for the refracting power of the eye being ſuppoſed to be ſuch, as will cauſe the focus of rays coming from the diſtance of three feet, to fall exactly upon the retina, it will not be able to collect together into the ſame point, rays which come from the diſtance of three inches; and the more diverging rays, when not collected by more powerful means, will be too late of uniting.

dxli. But thoſe rays, which come from very remote ſituations, and may be therefore reckoned parallel, would meet in the vitreous humour before they reached the retina; and would again ſeparate as rays from the point of concourſe, as if from a lucid point: it is therefore believed, that the powers, (dxxiii.) remove the cryſtalline lens from the cornea, and carry it nearer to the retina, that the rays may meet at a greater diſtance from the lens, and that that diſtance may be accommodated ſo as to fall upon the retina. For an eye, that will collect the rays coming from a diſtance of ſeven inches, on the retina, will collect thoſe which come from a diſtance of three feet too ſoon, and before they reach the retina. So that it ſeems perfectly neceſſary for the eye to be made thus changeable, ſince we ſee diſtinctly at various diſtances. The point of diſtinct viſion is that in which the given object is painted on the retina in the leaſt ſpace poſſible. The powers collecting the rays, are often very different

ferent in the two eyes of the ſame perſon, ſo that the one eye is rather long ſighted, and the other ſhort ſighted.

DXLII. Theſe and other ſimilar opinions, commonly received, are taught, more eſpecially by the mathematical phyſicians, who more obviouſly perceive the neceſſity of theſe changes. Yet there is no power in the human eye which can either move the cryſtalline humour from its place, or compreſs it. And we do not perceive this faculty in ourſelves: for we move a book, which by being too far off we ſee confuſedly, nearer to our eyes, which we would not do, if by an internal change in the eye we could correct the fault of the diſtance: and, through a ſmall hole, we perceive an object only ſingle in the point of diſtinct viſion, but double in every other. Perhaps the contraction of the pupil may have ſome effect in enabling us to ſee near objects more diſtinctly.

DXLIII. But this adaptation is not ſufficient in all perſons: for there are, and now more commonly than formerly, perſons leading a ſedentary life, and occupied with the obſervation of very minute objects, in whom the cornea is more convex and denſe; the cryſtalline lens more convex and ſolid; the eye itſelf, by the weight of the humours, more elongated; and the reſt of the humours themſelves probably more denſe; and in whoſe eyes one, or ſeveral, or all of theſe diſeaſes occur. In theſe perſons, the iris is ſenſible in a ſmall light; and therefore from their winking, they are denominated myopes. In theſe, the point of diſtinct viſion is very near to the eye, from one to ſeven inches from the eye; they ſee remoter objects obſcurely, without being able to diſtinguiſh their parts. The reaſon of this is evident; ſince, from the cauſes juſt mentioned, the too great refracting power of the humours, cauſes the diſtant and conſequently parallel rays to meet before the retina;

retina; and therefore diverging again from their focus, they fall upon the retina in many points. Thus alſo to a ſound eye, the perception of near objects is confuſed; becauſe the rays coming from theſe are ſpread all over the retina, without being collected.

DXLIV. The remedy, in the commencement of this diſeaſe, is to view diſtant places, to abſtain from minute objects, and concave glaſſes, and to look through a ſmall aperture, by which the light is weakened. When the diſorder is confirmed, it is alleviated by the uſe of a concave lens, which diminiſhes the refracting power in the humours, cornea, and cryſtalline lens, in proportion to its concavity; and thus removes the focus of diſtant objects farther from the cornea, ſo as to fall upon the retina. This glaſs ought to be a portion of a ſphere, whoſe diameter is equal to the diſtance of diſtinct viſion by the naked eye, ſquared by the diſtance of diſtinct viſion in the eye furniſhed with a glaſs, and divided by the difference betwixt them. Short ſighted people may hope for ſome relief from the progreſs of life; for children are almoſt all myopes; but, as they grow older, the eye becomes flatter from the ſtrength of the ſolids, it becomes ſhorter, and the converging powers of the lens and cornea are diminiſhed.

DXLV. Another defect, the oppoſite of the former, troubles people who are in the habit of looking much at very diſtant objects, and is eſpecially frequent and incurable in old people. In it, the cornea and cryſtalline lens are flatter, and the humours of the eye have a leſs refracting power. Hence near objects, whoſe rays fall very diverging upon the cornea, appear to them confuſed; becauſe the converging powers of the eye are not ſufficient to collect the rays into a focus upon the retina, and the rays arrive at it ſcattered, and have their focus behind the eye; hence their viſion is confuſed.

The

The point of diſtinct viſion among preſbyopi, is from fifteen inches to three feet.

DXLVI. Such perſons are, in ſome meaſure, relieved by looking through black tubes, by the uſe of which the retina grows tenderer, and the rays come to the eye in a parallel direction. The remedy here is a convex lens of glaſs, which may cauſe the rays to converge, ſo as to meet ſooner in a focus, and upon the retina. The diameter of the ſphere, of which ſuch a lens ought to be a portion, is exactly as before (DXLIV.) There is no hope from age, which increaſes the malady.

DXLVII. The medium betwixt the ſhort and long ſighted eye is the beſt, with which a perſon can ſee diſtinctly objects that are both tolerably near and tolerably remote, and therefore may aſſume the properties both of the myopes and preſbyopi; of this kind we reckon an eye that is able to read diſtinctly at the diſtance of one foot. But other conditions are neceſſary, ſuch as perfect clearneſs of the humours; great mobility of the eyes; ſenſibility of the pupil; and a retina, neither too ſenſible nor callous.

DXLVIII. But by means of the eye, the mind does not receive a ſimple repreſentation of the image of the object on the retina, which is transferred to the ſeat of the ſoul; but many things are added from experience, which the eye does not really ſee, and other things are interpreted differently by the mind, from what they are repreſented by the eyes. And, firſt, the magnitude of an object is judged of by the optical angle intercepted between the radiating object as the vertical point, and the cornea as the baſe. From hence, things very near ſeem large, and remote objects ſmall. To this may be referred the power of the microſcope, by which objects are made to appear to us ſo much larger, as the diſtance of the focus of the glaſs lens is leſs than the diſtance of diſtinct viſion; and,

and, in reality, they do not appear larger, but only more diſtinct and lucid; whence the mind judges them to be nearer.

DXLIX. In the ſame external light, the ſtrength of illumination depends upon the ſame angle, and upon the number of rays, joined with the ſmallneſs of the point which they affect in the retina; near objects therefore appear brighter, and diſtant objects more obſcure; or if remote objects appear bright by their own light, the mind repreſents them as large, or near, or both.

DL. The place of a viſible object is eſtimated by one eye, to be in a line comprehended by two other ſtraight lines drawn to the extremities of the body. If the ſame body is beheld with both eyes, it will then ſeem to be in the concourſe of two lines drawn through the axis of each eye to the object.

DLI. We do not ſee diſtance; and a blind man, who has never ſeen, on acquiring the uſe of ſight, imagines every thing he ſees to touch him. After much experience, we at laſt make conjectures about diſtances, though always fallacious: but we judge of them both from the diminution of the known bulk of the body, and from the diminiſhed ſtrength of the light, and faint image of the object whoſe parts we diſtinguiſh leſs evidently, and from the number of bodies interpoſed, whoſe diſtance is known to us.

DLII. Convexity is not ſeen; but from experience, a body is reckoned convex, after we have learned, that a body, which is convex to the feeling, cauſes light and ſhadow to be diſpoſed in a certain manner. It is convex if the ſhade be in the ſide correſponding to the left hand, and concave if in the right. Hence it is, that microſcopes frequently pervert the judgment, by tranſpoſing or changing the ſhadows. The ſame alſo happens in that phenomenon which is not yet ſufficiently underſtood,

derſtood, by which the concave parts of a ſeal are made to ſeem convex, and the contrary.

DLIII. The parts of a viſible object are judged by the mind to have the ſame ſituation which they have in the object, and not inverted as they are on the retina. The mind poſſeſſes this power of correction, previous to experience in men who have been born blind, and in animals at birth, as appears by indubitable experiments upon men, who had been blind from birth, and acquired the power of viſion ſuddenly by the operation of couching.

DLIV. Another falſe perception of the mind ariſes from this circumſtance, that external ſenſations conveyed to the ſeat of the ſoul by the eyes, are repreſented during almoſt the ſpace of a ſecond of a minute, to the mind as objects really preſent. Hence proceeds the idea of a fiery circle from the circumrotation of a lucid body; and hence the continuance of the image of the ſun, and ſometimes alſo of opaque bodies.

DLV. Do we perceive only that object diſtinctly which is directly before that part of the retina which ſees moſt diſtinctly? And does the mind perſuade itſelf, that it ſees many objects at a time, partly from the duration of the ideas, and partly from the quickneſs of the motions in the eye? Concerning perfectly diſtinct viſion, this is moſt certain; but we can hardly affirm it of that which is leſs diſtinct. Why do we ſee only one object with two eyes? Becauſe the ſenſation is ſingle, and without difference, when we have ſimilar impreſſions of two objects. For, even without the decuſſation of the optic nerves, inſects who have numerous eyes perceive objects ſingle. Hence the images of two objects excite only one ſenſation in the mind, when they fall upon the ſame point of the retina; but two ſenſations ariſe from one object, when the images fall upon different parts of the retina of each eye. Whence proceed diurnal and nocturnal blindneſs?

blindneſs? The latter is common to many nations living in the very warm climates, and under the vertical ſun, and to old men. The former happens in inflamed eyes, and in young men of a hot temperament, and hence furniſhed with eyes vaſtly ſenſible. For great ſenſibility of the retina produces diurnal blindneſs; inſenſibility produces nocturnal blindneſs. How do animals ſee in the dark? From a large dilatable pupil, tender retina, and refulgent and very lucid choroides. Why do we become blind when brought out of a ſtrong light into a weak one? Becauſe the optic nerve, having ſuffered the action of ſtronger cauſes, is not affected by weaker ones. Why is the ſudden tranſlation from a dark place into the light painful? Becauſe the pupil, being widely dilated, ſuddenly admits unawares too great a quantity of light, and the retina having been but ſlightly affected by the weak light, now feels the ſtronger impreſſions very acutely. Do we ſee with one eye, or with both? Moſt frequently with one, eſpecially and generally the right eye: but by the aſſiſtance of the other, we ſee more objects, and more plainly; and we alſo diſtinguiſh more points of the ſame object, and judge better of diſtances.

C H A P. XVII.

INTERNAL SENSES.

DLVI. WE have conſidered the ſenſes apart. It is common to them all, that the medulla of the tender and pulpy nerve, being affected by external objects, tranſmits ſome change by the nervous ſpirits, to that part of the brain where the fibres of the nerve affected firſt ariſe from the arteries of the brain (CCCLXXXII.) We know nothing more, than that new thoughts are excited

excited in the mind, as often as a change of this kind, originating in any organ of ſenſe, is tranſmitted to the origin of the nerve affected. For this perception is not an actual repreſentation of the object, by which the ſentient nerve is affected. The idea of redneſs has nothing in common with rays little refrangible, and ſeparated from the ſeven portions of the total ray; and much leſs is it conſiſtent with optical principles, for an image painted by rays upon a ſoft white nerve, to be conveyed for a long way, in perfect darkneſs, through a completely opaque body, to the origin of the thalami optici. There is nothing in the pain of burning that can repreſent to the mind the violent motion of a ſwift and ſubtile matter, by which the particles of the nerves are removed from mutual contact. There is nothing in the idea of a ſharp ſound from a cord of a certain length, that can inform the mind that the ſaid cord vibrates 5000 times in the ſpace of a ſecond. Neither does the taſte teach us that the cryſtals of ſea ſalt are of a cubical figure. Laſtly, motion imparted by a body perceived by the ſenſes, is indeed propagated to the brain, but the mind neither perceives this motion, nor the tremors of ſound, nor the percuſſion of the rays of light, but ſomething perfectly diſtinct from motion. It is eſtabliſhed as a reciprocal law by the Creator, that with certain changes, produced firſt in the nerve, and then in the ſenſorium commune, new and definite thoughts ſhall ariſe in the mind, invariably connected; and that our perceptions of external objects are arbitrary, yet that they are not falſe, appears plainly from the perpetual agreement of ſimilar ideas with ſimilar affections of the ſentient nerves, in all perſons at the ſame time, and in one perſon at different times.

DLVII. Therefore, when we feel, five very different exiſtences are conjoined: the thing which we perceive; the affection of the organ of ſenſe by that body;

body; the affection of the brain, arifing from the percuffion of that fenfory; the change produced in the mind; and, laftly, the confcioufnefs of the mind, and perception of the fenfation.

DLVIII. It appears from certain experiments, that the firft origin of every fentient nerve is always diftinct from all the others; and that the change which is firft excited by external objects in that nerve (DLVI.) continues long in its origin; and that thofe changes are generally fo arranged in the faid part of the brain, that, being difpofed according to the order of time, thofe are neareft together, which were either cotemporary, or occurred in immediate fucceffion; or, laftly, thofe which have a relation to the fame fubject, or were excited by fimilar objects; infomuch, that it is certain, that new ideas are conveyed to the fame part of the brain where others of the like kind are referved: for otherwife, neither would the arbitrary figns of words and letters recall to the memory paft ideas; or difagreeable ideas, returning into the mind, without the affiftance of external objects, reproduce the fame effects, as objects themfelves; nor, otherwife, could there be fo conftant and manifeft a connection of analogous ideas, which fupervene moft remarkably in dreaming, to the corporeal impreffions, acting at that time moft powerfully. Imagination and memory depend on this confervation of ideas. Thofe changes conferved in the fenforium, which many term ideas, are, for the fake of diftinction, by us called the impreffions of things, as they do not exift in the mind, but are impreffed in the body itfelf, and indeed in the medulla of the brain, in an incomprehenfible manner, by certain characters, incredible in their minutenefs, and infinite in their number. Amongft thefe the impreffions received by the fight are the moft remarkable, and moft diftinctly preferved, and next, thofe of hearing; thofe of the other organs are more confufed, and lefs re-

vocable

vocable by the will. Both the impreſſions and their ſigns are preſerved; the latter more eaſily; the former, however, ſo far, that a painter can expreſs with his pencil upon canvas, a face ſimilar to the image of a familiar face, impreſſed upon his mind.

DLIX. We are ſaid to imagine, when, by means of any image preſerved in the ſenſorial part of the brain, the ſame ideas are excited in the mind which would ariſe if the ſentient nerve that firſt produced the ſaid image itſelf ſuffered that change. This we term recalling an image. This definition is confirmed by the example of the great ſtrength of fancy in certain perſons, and in thoſe who are delirious, and in every perſon, in the inſtance of dreams, in which thoughts ariſe in the mind, occaſioned by the images preſerved in the brain, not at all weaker than thoſe which are primarily produced by the change in the ſentient nerve, from the external objects, and in which the perfect reſemblances of perſons and things with which we are occupied, are repreſented to the mind. Attention, quiet, and the abſence of other objects, even obtain a ſtronger aſſent of the mind to theſe traces impreſſed on the brain, than to thoſe perceptions which are excited in the mind by external objects: for the will is much more powerfully determined in thoſe who dream, than in thoſe who are awake; and ſome voluntary muſcles perform, during ſleep, functions, which, while awake, they never could perform, even when their nerves were moſt ſtrongly affected by the ſame object. From hence we may underſtand, how it is poſſible, that a very vivid internal impreſſion in delirium, may ſo impoſe upon the mind, as to be miſtaken for the perception of an external object; which is evident in the ſparks which are excited by rubbing the optic nerve; in the redneſs ſeen by the eye when ſhut; in the vertigo that ariſes from a motion of the retina, which we aſcribe to the external objects themſelves; in double viſion, &c.

DLX. Memory is ſaid to be exerciſed, when any thought of the mind, or image of an external object preſerved in the ſentient part of the brain, (CCCLXXII.) excites any perception in the mind. This is commonly weaker than in imagination, and almoſt confined to certain arbitrary ſigns, which the mind conjoined with that idea at its firſt perception. For memory hardly repreſents the images and pictures of things to the mind, but almoſt only words, and certain attributes, and abſtract ideas; for which reaſon, it excites volition leſs powerfully. But it appears from the obſervation of the phenomena of memory, that thoſe changes which ariſe from the external ſenſes, remain long in the brain; and ſometimes, if they made a ſtrong impreſſion, are repreſented to the mind for a long period, almoſt forever; but that they are gradually weakened and impaired; unleſs they be renewed, either by the object being repreſented again to the mind, or by the mind itſelf recalling the ſame change again into memory; and that at laſt the change will be in a manner eraſed, and entirely loſt, and the idea which was connected with that change by the law of nature, will never again recur to the mind. This annihilation is gradually effected by new and different impreſſions made on the ſenſorium, and not from time only, or the circulation of the blood, as in cataleptic patients, who ſometimes, after a conſiderable interval of time, return to the ſame train of thought which the diſeaſe had interrupted. But ſometimes all of them will be ſuddenly deſtroyed by ſome diſeaſe, in which the brain is in ſome way compreſſed, either by the blood or any other cauſe. Such a cauſe, acting on part of the common ſenſory, blots out a part of the impreſſions from the memory, ſuch as certain words, or all of them, the characters by which we expreſs words, or our friends, and even the neceſſaries of life: yet all theſe impreſſions may often be renewed by removing the

compreſſing cauſe. But the ſtrength and duration of an idea depend upon its being unuſual, exceſſive, or greatly conducing either to increaſe or leſſen our felicity; and, laſtly, upon our attention to it, and repetition; which laſt renders the impreſſions ſo vivid, that their perception is at length miſtaken by the mind for the perception of external objects, as in the caſe of maniacs.

DLXI. Moreover, if we review the hiſtory of human life, it appears, that in early infancy, we have hardly any memory; only ſimple perceptions, that ſoon vaniſh: which, nevertheleſs, excite ſtrong ideas in the mind, as we ſee from the crying of infants. The memory is perfected by degrees; and the ideas received from favorite objects, and familiar perſons, remain impreſſed in the mind of the infant; while, at the ſame time, the imagination likewiſe increaſes, which is often very powerful in young children; as, for example, in terror, which in no age produces more violent or deplorable effects. Afterwards, as the number of our ideas increaſes, the facility of preſerving paſt ideas is impaired, and, at the ſame time, the power of the imagination becomes torpid: till at laſt the former almoſt periſhes, and the ideas which are received eſcape from the brain in a ſhort time; while, at the ſame time, the imagination, which is a kind of memory, languiſhes.

DLXII. But ſince theſe perceptions produce various changes in the mind itſelf, which are perfectly diſtinct from any corporeal faculty, we ſhall briefly add ſomething concerning them, ſo far as may ſuffice for the purpoſes of medicine. Thought reſides in the ſoul, it attends to the ſenſations which are either brought by the ſenſes, or recalled by the imagination; frequently alſo to the mere ſigns which recur into the mind. Attention is when one idea occupies the mind principally or ſolely for any length of time. The compariſon of two ideas, inſtituted by the mind, is called judgment or genius,

when

when the mind, by comparing them, difcovers them to be alike or diffimilar. Genius confifts in a vivid fenfation conjoined with rapidity of thought, fo as inftantly to abftract from notions their points of fimilitude and diffimilitude. The principal fource of judgment, invention, and wifdom, confifts in the flow examination of ideas, by which they are confidered by the mind in every point of view, and in the attention of the mind being confined to one object, to the exclufion of all other ideas. Hence the efficacy of darknefs in making difficult calculations; the exquifite attention of blind people to the nature of founds; and of thofe who are deaf, to colours. The fources of error, are negligence in contemplating the whole idea, the eftimating it from a partial view, and the connection of ideas with others that are diftinct, and only related by accident, or external caufes.

DLXIII. The integrity of the judgment depends upon a healthy conftitution of the brain. For when that is compreffed, irritated, exhaufted of blood, or changed in its fabric, the ufe of reafon is totally difturbed; the ftrong internal impreffions on the brain are reprefented to the mind as external or real objects; the chain of ideas is broken, fo that the mind does not compare them, or perceive their refemblance or diverfity, but paffes abruptly from one idea to another totally different; or, laftly, the actions of the fenfes being impaired or interrupted, and all impreffions being in a manner erafed from the brain, man is reduced to a ftate of imbecility or vegetation. But external caufes alfo have confiderable influence in changing the relation of the mind to the impreffions of the fenfes; the air, way of life, food, and habit, either affift or diminifh the foundnefs of the judgment, the force of the imagination, and the ftrength of the memory.

DLXIV. Finally, as theſe ideas are either indifferent, or have ſome relation to our happineſs, they produce different determinations in the will. Some of the cauſes by which the felicity of our mind is either increaſed or diminiſhed, proceed entirely from the body, and are purely mechanical; amongſt theſe are pain, diſagreeable ſenſations, which ſeem to be produced by every ſenſation in a nerve that is too ſtrong, and pleaſure, in which the nerve is irritated beyond what is uſual, but in a moderate degree. Itching is akin to pleaſure, and in both the flow of blood is increaſed into the part in which either pleaſure or titillation is perceived; but, when farther increaſed, it degenerates into pain, or exceſſive ſenſation in the nerve. Anxiety is from the blood being retarded in its paſſage through the lungs. Other ideas which affect the mind, are either entirely unconnected with the properties of matter, or certainly leſs ſimple, underſtood, or mechanical, than the foregoing. The preſence of good conſtitutes joy; the deſire of good, love; the expectation of good, hope: the preſence of evil, ſorrow, terror, or deſpair; the diſlike of evil, hatred; and the expectation of evil, fear. Hope, curioſity, and glory, ſeem to be affections of the human mind, which neither belong to the body, nor exiſt in beaſts.

DLXV. From theſe affections of the mind, not only the pure will appears to direct the actions of the body to a foreſeen purpoſe, in order to attain good, and avoid evil, but alſo in the body itſelf, neither willing them nor capable of oppoſing them, various changes happen in the pulſe, reſpiration, appetite, ſtrength, and other functions of the heart, nerves, ſtomach, and other parts, which both immediately follow and indicate the paſſions of the mind. Thus anger violently excites the motion of the ſpirits, increaſes the motion of the heart, the frequency of the pulſe, and the ſtrength of the muſcles;

mufcles ; forces the blood into the ultimate and pellucid veffels, and even out of the veffels ; accelerates the excretion of bile, terminates chronic difeafes, and removes obftructions. Grief weakens the ftrength of the nerves, and action of the heart ; retards the pulfe ; deftroys the appetite ; and produces palenefs, cachexy, diarrhœa, jaundice, fcirrhofities, and difeafes arifing from a ftagnation of the humours. Fear diminifhes the force of the heart, fo as to occafion polypufes, and palenefs weakens the mufcular motions, relaxes the fphincters, increafes inhalation, and diminifhes exhalation. Exceffive terror increafes the ftrength even to convulfion ; excites the pulfe ; removes obftructions, palfies ; interrupts the courfe of the blood, and produces fudden death. Love, hope, and joy, promote perfpiration, quicken the pulfe, promote the circulation, increafe the appetite, and facilitate the cure of difeafes. Exceffive and fudden joy often kills, by increafing the motion of the blood, and exciting a true apoplexy. Shame, in a peculiar manner, retains the blood in the face, as if the veins were tied ; and alfo fuppreffes the menfes, and has been even known to kill.

DLXVI. In what manner are thefe changes produced by the refpective paffions of the mind ? Do nervous fphincters regulate the veffels, and at one time comprefs them fubfultorily, and increafe the motion of the blood, and at another relax them and deftroy their tone ? That fomething like this obtains in the fmaller veffels, appears evidently from the very fimilar effects produced by fear and cold upon the nerves of the fkin. In the genital parts, we manifeftly fee the veins, under particular circumftances, conftricted, and a confequent accumulation of blood : and it feemed probable, that in the larger veffels, the nervous noofes furrounding many of them produced the fame effects : for, in various

various parts, they ſurround and include the meningeal, temporal, vertebral, carrotid, ſubclavian, cœliac, meſenteric, renal, and other arteries. But after it was ſhewn by our experiments, that the nerves are at reſt during the action of the muſcles, and cannot be rendered ſhorter by any irritation, we were obliged to deſert this elegant theory. Nor would it ſeem far from the truth, that the arteries are rendered more or leſs irritable from the various ſenſibility of the nerves, and thus may be contracted more vehemently or languidly by the ſame quantity of blood, and that thus the motion of the blood is either quickened or retarded, if it were at all certain that the ſmaller arteries have the ſame irritable nature with the large ones. Thus the appetite and periſtaltic motion of the ſtomach and inteſtines, are manifeſtly deſtroyed by the affections of the mind.

DLXVII. It cannot be denied that the Creator has affixed characteriſtic marks to the paſſions of the mind, that in ſocial life man might not eaſily impoſe on man. For the reſpective muſcles, more eſpecially of the voice, face, and eyes, expreſs the ſeveral paſſions of the mind ſo faithfully, that they may be even repreſented in painting. To inveſtigate each of them, would indeed be an elegant taſk, but too long for this compendium. From the action of theſe muſcles being often repeated, phyſiognomy ariſes, ſo that the conſtant expreſſion of the face retains ſomething of the action of the prevailing muſcles; and ſome character of frequent anger often remains in the countenance, after the paſſion itſelf is gone off.

DLXVIII. Whence proceeds the ſympathy of parts, ſo famous in the practice of phyſic? In ſome of them it appears to depend upon the connection of the blood-veſſels; by which the blood, being repelled from one part, preſſes more heavily upon another, which has its veſſels from the ſame common trunk.

This comprehends revulſions made by blood letting; headach, from cold feet, &c. In other parts, the ſympathy ariſes from a ſimilitude in their fabric, by which they ſuffer like effects from the ſame cauſes ariſing in the body, ſuch as the ſympathy betwixt the womb and the breaſts. Another cauſe is, the continuity of membranes, from hence the itching in the glans of the penis from calculus, the cure of deafneſs by diarrhœa. Another cauſe exiſts in the nerves themſelves, and their anaſtomoſes, as ſatisfactorily appears from the teeth being ſet on edge by certain ſounds, a diſagreeable ſenſation being produced in the maxillary nerve, on account of its various communications with the portio dura. Thus the ſympathy of the eyes, which is not obſervable in like manner in the ears, proceeds from the decuſſation of the optic nerves; and vomiting is excited by nephritis. Laſtly, another cauſe is referred to the common ſenſory, and beginnings of the nerves, which is demonſtrated from general convulſions being produced by the irritation of a ſingle nerve, and univerſal epilepſy by a local diſorder, &c. Some ſympathies in diſeaſes ariſe from a tranſlation of the matter to other parts through the cellular ſubſtance, or by the action of the muſcles, arteries, or gravity.

DLXIX. But that important ſympathy remains to be explained, which ſubſiſts betwixt the body and the mind. For that the nature of the mind is different from that of the body, is proved by an infinity of circumſtances, eſpecially by ideas and affections of the mind, to which nothing in ſenſation is analogous. For what is the colour of pride? or what the magnitude of envy or curioſity? to which there is nothing ſimilar in animals; neither can that good which is deſired by it, glory and the acquiſition as it were of new ideas, be referred to any corporeal pleaſure. Is it poſſible that the body can poſſeſs two kinds of forces, ſo that its infinite particles

particles ſhould unite into one maſs, which do not preſerve their own affections only, and repreſent them to themſelves, but alſo join together into one common thinking whole, differing from the attributes of all, and yet capable both of receiving and comparing theſe attributes? Is there any inſtance of a body, which, without an external cauſe, paſſes from reſt to motion, changes or reverſes the direction of motion, without the action of ſome other cauſe, as is very eaſily obſerved with regard to the mind?

DLXX. Yet this mind, ſo different from the body, is connected with it by the moſt intimate ties, being both obliged to think upon thoſe impreſſions which the body preſents to it, and not ſeeming to poſſeſs memory or judgment, independent of the corporeal impreſſions on the brain; and, laſtly, by means of volition being the cauſe or occaſion of the greateſt and ſwifteſt motions of the body.

DLXXI. Thoſe have acted circumſpectly who, confeſſing themſelves ignorant of the manner in which the body and mind are united, have contented themſelves with the laws eſtabliſhed by the Creator, which they have aſcertained, and not conjectured. They are manifeſtly excuſed by the obſervation, (DLVI.) that even in optics, it is very certain that the affections of the body are connected with the thoughts of the mind, by an arbitrary relation, and that other ideas would have been ſuggeſted, if the Creator had altered the figure, the refracting power, or colours of the parts of the eye. As there is a law, which eſtabliſhes a perpetual connection between the leaſt refrangible rays and the idea of a red colour; there is alſo a law which conſtitutes the connection betwixt the impreſſion of thoſe rays upon the retina, and the correſponding idea. Nor need we be more aſhamed of our ignorance of the mechaniſm of the latter law, than of our ignorance of the nature of the former.

DLXXII.

DLXXII. Does the mind govern the body? Do all the motions and actions in the body arife from the mind, as the immediate fource and origin of motion? Do the motions of the heart, arteries, and refpiration, arife from the mind, willing them and folicitous for the common good of the whole fyftem? Is this power of the mind demonftrated by the ftructure of polypi formed in wounds, by the paffions of the mind, and by the nævi materni? Is the abfence of confcioufnefs accounted for by the well known example of the obfcure perceptions we have in refpiration, winking, and mufcular motion, all of which are effected by the will, although we do not know the organs, or attend, that we will, when we breathe, wink, or walk, when occupied in thought? Is it therefore certain, that all motions arife from the mind, becaufe there is no other evident caufe perpetually connected with the body, to which they can be referred?

DLXXIII. There are many reafons which do not yet permit us to adopt this opinion. And, firft, the conftruction and government of the body itfelf appear greatly to exceed the wifdom of the mind. Our mind fees one point diftinctly, (DLV.) and thinks one thought diftinctly; but if it endeavours to fee two objects at the fame time, to contemplate two ideas at the fame time, or to read two letters at once, it always becomes confufed, commits miftakes, and comprehends neither rightly; and confcious of its own powers, whenever it applies ferioufly and diligently to any object, it withdraws itfelf as it were from the impreffions of fenfe, and neither fees, nor hears, nor fmells, nor performs mufcular actions. But the mind ought to be capable of infinite and diftinct thoughts, in order to be able to govern fuch an infinite variety of mufcles, veffels, and fibres, in a manner accommodated to the moft exact geometry; and to refolve and conftruct occafional problems in the direction of the muf-

cles,

cles, ſcarcely ſoluble by the higheſt geometry: and yet we muſt conclude the mind ignorant of this immenſe taſk, and at the ſame time, over and above all thoſe works, capable of contemplating the moſt difficult and abſtract ideas; ſo that neither the care of the body diſturbs its meditations, nor its meditations interfere with the neceſſary motions of the body.

DLXXIV. Moreover, if, without being conſcious of volition, we can will to reſpire, or wink, and with effect; we neverthe leſs retain our control, and can ſuſpend reſpiration, and keep the eyelids firm, and alternately excite their actions, and therefore we never loſe either the conſciouſneſs of our control, or the uſe of it. But we are not able to perform any thing of this kind in the heart or inteſtines; we cannot reſtrain their motion, when too quick, or excite them when languid. Amongſt all mankind, why does every one govern his reſpiraton? why in all ages no one his heart? If cuſtom only is the cauſe of our inconſciouſneſs of this power, why is not the mind ſenſible of its action, in moving the heart, or in exerciſing the periſtaltic motion, after being ſuſpended for hours, or even whole days, in ſwoons, in hyſteric fits, and in aſphyxia?

DLXXV. But it is evidently falſe, that all motions ariſe from the mind, and that without it matter would be an immoveable inert maſs: for the contractility excitable by every ſtimulus, to which the motion of the heart, inteſtines, and perhaps all the other motions in the human body, belong, (CCCCXCI.) does not require the preſence of the mind; it continues in the dead body; it is excited by mechanical cauſes, heat, and inflation; and it does not deſert the fibres, until they become ſtiff and cold, although the mind, which perceives and wills, may have been a long time expelled by the deſtruction of the brain and heart, and even although

although the muſcle, by being taken out of the body, has been ſeparated from every imaginable connection with the mind.

DLXXVI. Little, if any, reliance is to be put in the nævi materni, as is noticed in another place. That the direction of the vital motions, in diſeaſes, is not regulated by prudence, but almoſt entirely by the power of ſtimulus; we are explicitly taught by the moſt ancient and only certain practice, which reſtrains the exceſſive motions in acute and intermitting febrile diſeaſes, by the uſe of blood letting, opium, nitre, Peruvian bark, &c. The ſage has no prerogative in the government of his body, over the mereſt ideot; and that the fœtus, which even at birth is ignorant of the motions of its muſcles, and learns by experience to walk, to ſwallow and to ſee, conſtructs its body, fabricated with ſuch incredible art, is an affirmation ſo repugnant to probability, and ſo abſurd, that of itſelf alone it is ſufficient to refute the hypotheſis.

DLXXVII. The ſtate of aptitude for exerciſing the ſenſes and voluntary motion, in healthy organs, is called wakefulneſs. Indiſpoſition to ſuch exerciſe, and their perfect reſt, with healthy organs, is called ſleep.

DLXXVIII. In ſleep, the mind either thinks not at all of what ſhe knows or retains in memory; or only attends to the traces of paſt objects repoſited in the common ſenſory, (DLVIII.) the vivid repreſentations of which excite altogether the ſame perceptions in the mind as are made by the impreſſion of external objects upon the organs of ſenſe. Theſe repreſentations are called dreams; and have the effect, that while the reſt of the emporium of the ſenſes and muſcular motion is at reſt, ſome part remains open, is pervaded by the ſpirits and watches. Sometimes certain voluntary motions are conjoined with theſe perceptions of the mind, ſo that the organs of ſpeech, many, or all of the

limbs,

limbs, are directed by these perceptions, as in somnambulists.

DLXXIX. But, during sleep, the motion of the heart proceeds, and also the distribution and circulation of all the humours in the body, the peristaltic motion of the stomach and intestines, and the action of the sphincters. Lastly, the respiration itself continues to be performed in like manner. This conjunction of the quiescence of certain organs with the motion of others, renders a knowledge of the mechanical cause of sleep difficult.

DLXXX. Therefore, in order to investigate it, we shall consider all the causes, and all the phenomena, both of sleep and vigilance, and trace them in all kinds of animals. For that condition, which is produced alike by all those causes, will be the true cause of sleep. Sleep naturally follows vigilance and the labours of human life. For when awake, there is almost a continual motion of the voluntary muscles, and of the organs of the senses, and the affections of the mind continually impart new stimuli to the nerves, blood-vessels, and heart. Thus the blood, by continual motion and trituration, is altered from a bland nature to an alkaline putridity; while the more subtile spirits are dissipated faster than they are replaced, and gradually not only debility and lassitude of the body are induced; and, if the want of sleep be protracted too long, also feverish heat, acrimony of the humours, and loss of strength. On the return of night, torpor is perceived in all the long muscles; the mind becomes unfit for deep thought, and the desire of rest pervades both mind and body. At this time, the powers which hold the body erect, suffer particularly; the eyelids close involuntarily, the lower jaw falls down, the necessity of yawning increases, the head nods forwards, the circumstances of external objects affect us less; and lastly, the ideas and thoughts become disturbed, and a delirium

rium enfues; from which the tranfition to fleep is not perfectly known; but which invariably precedes fleep. In this natural fleep, which is common to all animals, the caufe feems to be a deficiency of the nervous fpirits, which have been in fome manner confumed by mufcular motion, and the exercife of the fenfes, and of which probably a great quantity is exhaled.

DLXXXI. The abfence of every irritation of the head, and other parts of the body, the perfect reft of the mind and external fenfes, and darknefs, have great influence in promoting fleep.

DLXXXII. Again, a variety of caufes which debilitate, induce, and increafe fleep; fuch as great loffes of blood, venefection, cooling medicines, opiates, and coldnefs of the atmofphere, and alfo applications which derive the blood from the head, as warm bathing of the feet, and a plentiful meal, which always produces fleep in all kinds of animals.

DLXXXIII. On the contrary, again, various hot medicines induce fleep, by accelerating the flow of blood to the brain; fuch as wine, fpirits of all forts, but more efpecially when refolved into vapour, opium, hyofcyamus, the indigeftible particles of our aliments, acute and malignant fevers of various kinds; or by retarding the return of the venous blood, as fatnefs. All thefe caufes feem to concur in this, that the blood being collected in the head, compreffes the brain and intercepts the courfe of the fpirits into the nerves.

DLXXXIV. But likewife mechanical caufes produce fleep; for example, every compreffure of the dura mater and brain, whether from extravafated blood, a depreffed bone, or a collection of water in the ventricles.

DLXXXV. Sleep, therefore, arifes either from a fimple abfence, deficiency and immobility of the fpirits, or from compreffion of the nerves; and always

ways from the motion of the ſpirits through the brain being impeded.

DLXXXVI. This theory is confirmed by the cauſes of vigilance: for all thoſe things prevent ſleep which produce plenty of ſpirits; more eſpecially warm aromatic drinks, which ſend minute ſtimulating particles to the head; by which the motion of the blood is moderately quickened through the brain, and, being at the ſame time more diluted, it ſecretes more ſpirits in a given time.

DLXXXVII. Sleep, again, is prevented by cares of the mind, attentive and intereſting meditation, and pain of body and mind; all of which prevent the ſpirits in the ſenſorium commune from reſting, and the nerves from collapſing. Therefore, the former cauſes increaſe the quantity of the ſpirits, theſe increaſe their motion. And, therefore, we return to our former concluſion (DLXXXV.) namely, that the nature of ſleep conſiſts in the collapſe of the nerves, proceeding from the ſenſorium commune.

DLXXXVIII. Is the region of ſleep, therefore, in the ventricles of the brain? It is inconſiſtent with the univerſality of ſleep, which extends to animals which have no ventricles in their brain. Do the vital actions continue during ſleep, becauſe it is an affection peculiar to the brain, and independent of the cerebellum? And what is the cauſe of this diverſity, which occaſions the animal functions to reſt during ſleep, and the vital functions to continue? It is that already mentioned, that vital motions are prevented from reſting by perpetual ſtimuli, and perpetually exciting cauſes, (CCCXCII.)

DLXXXIX. The effect of ſleep is the abatement of all the motions in the human body. For now the action of the heart alone remains to propel all the humours, while all the motions of the muſcles and ſentient nerves, and thoſe originating from the paſſions of the mind and volition, are removed; by which, while awake, the courſe of the blood and ſpirits

ſpirits was promoted, as well as by the heart (DLXV. CCCCXVII.) The heart gradually returns from its quick and almoſt feveriſh pulſation, to its morning ſlowneſs; the breathing becomes leſs and ſlower, the periſtaltic motion of the ſtomach and inteſtines, hunger, digeſtion, and the progreſſion of the feces, are all diminiſhed; the thinner juices move more ſlowly, while the more ſluggiſh are collected together, and the effuſed fat is accumulated; the nouriſhing jelly adheres more plentifully to its fibres and cavities; the conſumption of the ſpirits, the attrition of the blood, and the quantity of perſpiration, are all diminiſhed. Thus, while the nervous fluid continues to be ſecreted, and its conſumption to be diminiſhed, it is by degrees accumulated in the brain, ſo as to diſtend and fill the collapſed nerves, and from the acceſſion of the ſlighteſt ſtimulus, both the internal and external ſenſes are excited to action, and the ſyſtem is awakened. Sleep, continued for too great a length of time, diſpoſes to all the diſorders that attend ſlowneſs of circulation, to fatneſs, drowſineſs, and cachexies; and is highly detrimental to the memory.

DXC. Whence the yawning of thoſe about to ſleep? To promote the paſſage of the blood through the lungs, which is now ſlower. Whence the ſtretching of the limbs? To overbalance, by the influx of the ſpirits, the natural contraction of the muſcles, by which all the limbs are put in a moderate degree of flexion, and ſo to reſtore ſtrength to the extenſor muſcles. Whence the opinion, that, during ſleep, the motion of the heart becomes ſtronger, and the perſpiration more plentiful? From the heat of the bedclothes, by which the perſpirable matter being confined, ſoftens and relaxes the ſkin. But any one that ſleeps in his uſual garments, grows colder; and animals which ſleep through the winter, become exceſſively cold, as dormice and hedge-hogs. Why do all animals grow ſleepy after taking food? Not

Not from preſſure upon the aorta, or congeſtion of blood in the brain; for even animals which have ſcarcely any brain, ſleep after food. Do the indigeſtible particles of our aliments, by paſſing leſs eaſily through the brain, and compreſſing its medulla, render the ſleep leſs refreſhing? Is dreaming perpetual and inſeparable from ſleep? Is it ſo far natural, and a kind of ſubſtitute for ſenſation to the mind, that it may never be without thought? This does not ſeem probable. We rather aſcribe dreams to ſome morbid ſtate, or to ſome ſtimulating cauſe, interrupting the perfect reſt of the ſenſorium. Hence that ſleep refreſhes moſt which is without dreams, or at leaſt without the remembrance of them. Hence they are generally wanting in the firſt ſleep, at which time the ſpirits are moſt exhauſted, and return in the morning when theſe are in ſome meaſure repaired. Hence care, the ſtrong impreſſion of ſome idea upon the memory, indigeſtible food, exceſs, or any uneaſy poſture of the body, occaſion dreams; for they are uſually generated by ſome ſenſation, with which, according to the laws of the aſſociation of ideas, the whole collection of ſimilar impreſſions connect themſelves.

CHAP. XVIII.

OF MASTICATION, SALIVA, AND DEGLUTITION.

DXCI. HARD and tough articles of food, conſiſting of long parallel fibres, or covered with a bony ſhell or cartilaginous integuments, and friable ſubſtances, generally require maſtication, to divide them into ſmaller and leſs cohering parts, that they may the more eaſily yield to the diſſolving powers of the ſtomach. The more completely they are ſubdivided in the mouth, they become

come the more ſapid, approach the nearer to the nature of a fluid, and are digeſted the more eaſily.

DXCII. Therefore moſt animals are provided with extremely hard teeth, each having a bony, hollow root receiving, through a ſmall hole in the apex of its cone, little blood-veſſels, and a nerve, which go to its internal perioſteum; fixed by the whole root into the alveolus adapted to it, and, in the upper part of its crown, ſtrongly tied down by the adhering gum. But the upper part of the teeth placed above the gums, is not bony, but of a peculiar ſtructure, much harder and denſer, reſiſting putrefaction in the dead body, and almoſt vitreous, compoſed of ſtraight fibres vertical towards the root, and running together in the middle. This portion has neither perioſteum nor veſſels, and being perpetually waſted, ſeems to be as often repaired by ſome fluid which aſcends from the follicle of the root. The teeth are therefore well adapted for overcoming the hardneſs of other bodies, and for comminuting the food.

DXCIII. As the materials of our food are various in their texture and firmneſs, nature has accordingly diverſified the ſtructure of the teeth. In man, the anterior teeth, four in each jaw, are weaker than the reſt, have a ſingle root, and a crown inwardly concave, outwardly convex, extenuated like a wedge, and terminated by a rectilineal edge. They are deſtined for dividing, into ſmaller portions, the ſofter foods, which are merely tough, and for comminuting the fibres and membranes of animals and vegetables, and the kernels of fruits.

DXCIV. The ſecond ſpecies is the canine teeth, of which there are two in each jaw, fixed by a longer and ſtronger, but ſingle root, with a crown of a conical ſhape. Theſe lacerate tough aliments, and hold faſt thoſe which require much trituration.

DXCV. The third order is the grinders, which in general have ſeveral roots, and a quadrangular crown, with a flat ſurface, but divided by chequered aſperities. The two anterior ones are weaker, have one or two roots, with the ſurface of their crown parted into two; the three poſterior grinders are larger, fixed by three, four, and ſometimes five roots, but generally by one leſs in the lower jaw, with a flat ſurface, quadrangular, and commonly divided into as many eminences as there are roots. Betwixt theſe teeth, the bony articles of food are interpoſed and broken, the hard are bruiſed, while the lower teeth, being moved obliquely and laterally, are rubbed againſt the immoveable upper ones: by theſe the functions of the teeth are principally performed.

DXCVI. That the teeth might poſſeſs mobility combined with ſtrength and firmneſs, the upper ones are fixed into the ſockets of the immoveable upper jaw, the lower ones into the lower moveable jaw, which is a ſingle bone, and articulated with the temporals, in ſuch a manner that it may be drawn down from the upper jaw, and raiſed up againſt them with great force; and may be moved laterally to the right and left, and forwards beyond the upper jaw, and backwards to its firſt ſituation. Theſe motions depend upon the articulation of its condyles, (in which the lateral parts of the lower jaw terminate, and which are broadeſt tranſverſely, and convex in the middle,) with the oblique tubercles of the temporal bones, which are hollowed at the root of the jugal proceſs, deeper in the middle, and increaſed by a little flat ſurface of the ſame kind, before the auditory paſſage, from which it is ſeparated by a peculiar fiſſure. This joint has greater liberty in moving, and a durable cartilaginous cruſt, from a cartilage interpoſed between the condyle of the lower jaw and the tubercle of the temporal bone, on both ſides concave

concave in its middle, with raiſed edges, correſponding by the former to the tubercle of the temporal bone, and by the latter to the adjacent depreſſions.

DXCVII. The muſcles moving the lower jaw, which in man are weaker, but very ſtrong in brutes, are the temporalis, an elevator, ariſing from a large part of the ſide of the ſkull, and from its aponeuroſis, collecting its tendinous fibres, intermixed with muſcular fibres, in a ſtellated manner, into the ſharp proceſs of the jaw; the maſſeter, an elevator, deſcending double or triple from the jugum and margin of the cheek bone backwards into the coronoid proceſs. Theſe act in concert; but the temporal muſcle carries the jaw more backwards, the maſſeter more forwards. The pterygoideus internus deſcends from the pterygoid foſſa, and from the palate bone and root of the little pterygoid proceſs, and its internal wing, into the angle of the lower jaw, which it elevates when depreſſed by its antagoniſts, or draws to one ſide. The pterygoideus externus has a double origin; the one tranſverſe from the inner wing and adjacent bone of the palate, and poſterior convexity of the upper jaw: the other, deſcending, ariſes from the hollow temporal part of the great wing of the ſphenoides; thence it proceeds backwards and downwards into the outer part of the condyle of the lower jaw, which it draws forwards before the upper jaw, and to one ſide.

DXCVIII. The lower jaw is depreſſed, and the mouth opened by the digaſtric muſcle, ariſing from a hollow of the mamillary proceſs, tied by its middle tendon with much firm cellular ſubſtance, of a tendinous nature, to the os hyoides; likewiſe connected to the mylohyoideus, and paſſing through the deſcending fibres of the ſtylohyoideus, increaſed by another fleſhy belly, and inſerted at the ſymphyſis of the two halves of the lower jaw. More-

over, the mouth may be opened by all the other muſcles, inſerted into the inferior maxilla, os hyoides and larynx, as the geniohyoideus, mylohyoideus, genioglosſus, ſternohyoideus, ſternothyroideus, coracohyoideus, and latiſſimus colli; although the latter rather draws the ſkin of the neck and face downwards. The geniohyoideus and digaſtric muſcles draw the jaw backwards.

DXCIX. The lower jaw is elevated with great force, and the lower teeth being carried up againſt the upper teeth, divide the food, by the action of the temporal, maſſeter, and internal pterygoid muſcles; which appears by undoubted experiments to be very powerful, and ſufficient to raiſe ſeveral hundred weight. The lateral motions of the jaw, and its circular motion around one condyle as a fixed point, are performed by the external and internal pterygoidei, and by the former muſcles acting ſingly and alternately. Thus the food is cut, broken and bruiſed; and if the maſtication be rightly performed, it is reduced into a kind of pulp.

DC. Before the teeth there is placed a cutaneous and fleſhy ſack, which is every where produced from the integuments of the face; and incloſes a hollow ſpace with both rows of teeth when ſhut. The lateral parts are called the cheeks, the middle the lips. From this cavity there is a paſſage, betwixt the teeth, into the mouth, which on the upper part is bounded by the bony and ſoft palate, underneath by the muſcles lying under the tongue, and on the forepart by the teeth. On the back part it opens between the ſoft palate and tongue into the fauces. The tongue divides the cavity of the mouth in the middle, and is eaſily moveable to every part of it.

DCI. During the trituration of the food in the mouth, there is continually poured to it a large quantity of a watery clear liquor, evaporable, inſipid,

pid, or very little faline, containing a very fmall quantity of earth, and neither acid nor alkaline, although from it a very fmall portion of lixivial falt may be obtained; of which all around are numerous fources. A large quantity of this faliva is fecreted by innumerable oval glands in the lips and cheeks, and by fome larger ones which are placed round the mouth of the parotid duct; and laftly, by the pores of the hard palate, pouring out the liquor, which they fecrete, through a little fhort duct and hole. The fluid effufed by the exhaling veffels of the cheeks, and back of the tongue, is fimilar, or more watery. It is now afcertained, that the ductus incifivus is impervious, and tranfmits nothing but the artery, which goes from the palate to the noftrils.

DCII. The faliva is a watery liquor, with a fmall quantity of falt, partly lixivial, and partly culinary; with fome oil and earth, evaporable by the fire; with fcarcely any tafte, unlefs when fharpened by difeafe or hunger. The quantity produced is confiderable, as twelve ounces have been known to flow out from wounds in the fpace of an hour. By well bred people, it is for the moft part fwallowed; and ufefully, as it cannot be thrown away without hurting the digeftion.

DCIII. The falivary glands efpecially fupply the faliva. Of thefe, the principal is the parotid, extenfively filling up the interval between the auditory paffage and the lower jaw, and covering the jawbone where naked, and part of the maffeter. It is a conglomerate gland, with round acini, connected by cellular fubftance; which more denfely compacted, forms a kind of involucrum, almoft tendinous, to the whole gland. Its duct is white, vafcular, and capacious, afcending from the bottom of the gland to the jugum, from whence it is tranfverfely inclined, and receives the duct of a gland, feated on the top of the maffeter, which is either

continuous

continuous with the parotid, or diſtinct from it, and rarely double; after this, bending round the tumid edge of the maſſeter, it opens with an abrupt termination, without a papilla, through the ſeparating fibres of the buccinator, ſurrounded by many little glands of the cheek. The bulk of this gland, and the number of its arteries, render it the chief ſource of the ſaliva.

dciv. Another ſmall gland, adjacent to the parotid, but twice as ſmall, compoſed of ſofter and larger acini, connected by a ſimilar membrane, is contiguous to the corner of the lower jaw-bone, and being in part ſubcutaneous, terminates upon it, and in part ſends off an appendix over the mylohyoideus muſcle, which running along the long concave ſide of the lower jaw, of a granular fabric, and ſpread under the membrane of the mouth, is called the ſublingual gland. From the larger maxillary gland, a duct paſſes out along with this appendix, covered by the middle part of the ſublingualis, from which it receives one, two, or three branches; by whoſe inſertion being increaſed, it opens into a projecting membranous cylinder, ſeated on the bridle of the tongue. But other ſmall and ſhort ducts from the ſublingual gland, three, four, or more, even to the number of twenty, perforate the edge of the tongue in the line continued backwards from the frenum, with ſhort little ducts and points, and ſecrete ſaliva. There are inſtances where the larger anterior branch of this gland, which uſually joins itſelf to the duct of the maxillary gland, goes on ſingle, and parallel to it, and opens by itſelf. Some other glands alſo, ſimilar to thoſe of the cheeks, which however may be reckoned among the ſublinguals, by their proper ducts perforate the membrane of the mouth where it departs from the tongue. Various other ſalival ducts have been intimated by different perſons, but they are not confirmed by anatomy.

dcv.

dcv. The Creator has wifely provided, that maftication cannot be performed, without the falival glands being compreffed by mechanical neceffity, fo as to difcharge their fluids in an increafed quantity. For, when the mouth is opened, the maxillary gland, being preffed by the digaftric and mylohyoideus, throws forth a fountain of faliva; the parotid gland is compreffed by the maffeter, when fwelled, and by the cutaneous mufcle of the neck which lies over it: hunger has the fame effects with mufcular preffure, and caufes a flow of faliva into the mouth.

dcvi. The food, therefore, being ground between the teeth, with the watery faliva and air, is broken down into a foft fucculent, figurable pulp, replete with elaftic air, which being heated by its fituation, on account of its elafticity, perpetually tends to the diffolution of the particles of the food between which it is included. By this procefs, the oily and aqueous parts of the food are intermixed; the fmell and tafte of different ingredients are blended together; and, at the fame time that the faliva dilutes the faline parts, the food becomes fapid. Such particles as are volatile, are directly abforbed by the bibulous veffels of the tongue and cheeks, and recruit the ftrength, by being reftored to the blood-veffels and nerves.

dcvii. But the motions which are neceffary for turning round the food in the cavity of the mouth that it may be introduced between the teeth, are effected by the tongue, cheeks, and lips. And efpecially, the tongue being at one time expanded, receives the food into the fmall concavity in its furface; and being moved by its proper powers, (ccccl.) conveys its load to the part defigned. At another time, the tongue contracted, and narrow, fearches every part of the mouth with its tip, and collects together the food into one heap. At another time, by applying itfelf to the teeth, it draws from

from the cavity of the cheeks the fluids or chewed aliments, and conveys them to the posterior cavity of the mouth, situated behind the teeth.

DCVIII. But these motions of the tongue are likewise governed by the os hyoides, which is extensively connected with it by muscles and membranes, and is composed of a basis, concave inwardly, of horns extending outwardly, and terminated by a thicker knob, and of oval cornicles. When drawn down by its respective muscles, it carries back the tongue at the same time, and also depresses the lower jaw, if the muscles of that be relaxed. These powers are the sternohyoideus, but arising also in part from the clavicle, which is extenuated upwards, and striped with tendinous lines: the sternothyroideus, which is broader, and arises from the same place, and also from the upper rib; on depressing the cartilage, into which it is inserted, it necessarily forces the os hyoides connected with it, to descend: it is intermixed with the hyothyroideus and thyreo-pharyngeus, and every where intermixed with the sternohyoideus: the coracohyoideus, but which arises obliquely from the upper and shorter side of the scapula, near its notch; where crossed by the jugular vein, it becomes tendinous; with its upper belly, it is straight, and pulls the os hyoides directly downwards; it is every where blended with the sternohyoideus, and the hyothyroideus, which is governed by the former muscles.

DCIX. Other powers elevate the os hyoides, together with the tongue. The styloglossus muscle, sustained by a peculiar ligament from the upper jaw, which is sometimes fleshy. The stylohyoideus, a weak muscle, often split for the passage of the biventer, and again collected into two portions, adhering to the tendinous expansion of the biventer, and inserted by the one portion into the basis of the os hyoides, and by the other portion into the horn, and mixed with the tendinous expansion of the

the mylohyoideus. The ſtylohyoideus alter, when it is preſent, reſembles the former, behind which it is placed; ariſing from the tip of the ſtyloid proceſs, and inſerted into the oſſa triticea, it anſwers the purpoſe of a ligament to ſuſtain the os hyoides. All theſe muſcles draw the tongue back, and elevate its ſides. The mylohyoideus, ariſing from the whole length of the jaw, combining into one with its companion, elevates the tongue, and gives it firmneſs for various motions, or elſe it depreſſes the jaw. The geniohyoideus, accompanying the genioglofſus, pulls the tongue forwards out of the mouth.

DCX. But, moreover, the muſcles of the cheeks variouſly move and compreſs the food in the mouth. Some carry it from the cavity of the cheeks into the cavity of the mouth behind the teeth, as the buccinator when the mouth is ſhut. Others open the mouth for receiving the food; ſuch as the double headed proper elevator of the upper lip, and the elevator communis in part, the naſalis labii ſuperioris, both zygomatici, the riſorius, tariangularis menti, and the depreſſor proprius anguli oris, which, ariſing on each ſide from an excavation near the ſocket of the canine tooth, is inſerted into the orbicularis. Others, again, ſhut the mouth, that the food received may not fall out; ſuch as the orbicularis of each lip, the proper depreſſor of the upper lip, and the proper elevator of the lower lip, and the elevator communis in part. Of theſe, more particular deſcriptions may be had from profeſſed ſyſtems of anatomy.

DCXI. By theſe means the food, mixed with and ſoftened by the ſaliva, is collected from all ſides, behind the teeth, and is committed to the tongue, expanded by the ceratogloſſi and geniogloſſi, and rendered a little concave by the ſtylogloſſus, from thence it is next conveyed to the fauces.

DCXII. The tongue being raiſed by the ſtylogloſſi, and extenſively applied to the palate, firſt

with

with its apex, then gradually with its poſterior extremity, preſſes the food towards the fauces, at that time the only open paſſage. After this, the thick root of the tongue itſelf reſiſts the larynx, which is drawn upwards, and preſſes down the approaching epiglottis, which ſtands up behind the tongue, and is connected with it by numerous membranes, and perhaps by ſome muſcular fibres. At the ſame time, all the muſcles elevating the pharynx act together; the biventer, geniohyoideus, genioglоſſus, ſtylohyoideus, ſtylogloſſus, ſtylopharyngeus, and others, and draw the larynx upwards and forwards, ſo that the epiglottis preſents itſelf oppoſite to the tongue, and is more eaſily inclined. Hence it is neceſſary for deglutition, that the jaws be cloſed, or at leaſt that the lower one be raiſed, and fixed in that poſition, that the biventer, and the other muſcles already mentioned, may derive ſtability from it, and elevate the os hyoides. Thus the epiglottis, being turned down, ſhuts up the paſſage to the larynx ſufficiently and largely, and over it, as over a bridge, the food paſſes into the fauces.

DCXIII. By the pharynx we underſtand an ample ſhapeleſs cavity, bounded behind by all the vertebræ of the neck, and the occipital bone before the foramen magnum, in the middle by the cuneiform bone, and before by the opening of the nares, the moveable velum of the palate, the mouth, the tongue, and the larynx: below it is continued into the œſophagus. Its ſides are formed by the lower jaw, the cheeks, the velum of the palate, the pterygoid proceſs, the ſtiliform appendix, the tongue, os hyoides, and larger cartilages of the larynx. It forms one ſoft membranous bag, outwardly ſurrounded on all ſides by muſcular fibres. Its internal membrane is continuous with the cuticle, and renewable, but more moiſt. Outwardly the pharynx is covered by a good deal of cellular ſubſtance, more eſpecially in its poſterior and lateral parts. Therefore it is lax and

and dilatable, and fitted for receiving all bodies that are preffed by the tongue over the larynx.

dcxiv. It is dilated in the action (dcxii.) by the powers elevating it, by the ftylopharyngeus, which defcends fometimes double into the membrane of the larynx, under the os hyoides, and into the margin of the thyroid cartilage, and is largely diftributed over the internal furface of the pharynx, together with the following mufcle; the thyreopalatinus, fpread in the form of an arch round the moveable palate, and forming two columns, which defcend along the fides of the pharynx, and form a confiderable part of that bag, being alfo connected by broad fibres to the thyroid cartilage. That the falpingopharyngeus is a true mufcle, I am ready to believe, rather from the obfervations of eminent anatomifts than from my own. Of the cephalopharyngeus, I am doubtful, unlefs you reckon the ftrong white cellular fubftance, which occupies the upper part of the pharynx, as a mufcle. Drink paffes round the larynx on each fide of the epiglottis, and falls into the œfophagus.

dcxv. The aliments are prevented from regurgitating into the noftrils when they arrive at the dilated pharynx (dcxiv.) by the palatum mobile, which is interpofed. Anteriorly from the bony palate, and laterally from the pterygoid wings, is continued a moveable velum, compofed of the membranes of the mouth and noftrils, with intervening mufcles and glands, almoft of a fquare figure, and hanging betwixt the cavity of the nares and mouth, into the hollow fauces, in fuch a manner that it naturally leaves the former open, and is concave towards the mouth: the middle lower portion of this, extended into a conical fhape, pendulous, before the epiglottis, and replete with many glands, from its appearance in a difeafed ftate, is called the uvula. At each fide of the velum, two arches defcend from the velum palati, of which the fmaller and thinner goes

to

to the tongue, the larger to the pharynx. The elevator of this velum, which is ſtrong, ariſes from the aſperities and plane ſurface of the os petroſum, behind the ſpinal foramen, and alſo from the cartilage of the Euſtachian tube, deſcends inwards with its companion, forms an arch in the velum mobile, between the two plates of the thyreopalatinus muſcle. It may therefore draw that velum to the nares and tubes, that the food may not enter either of them. But, during deglutition, it does not ſeem to have any conſiderable action. At this time regurgitation into the noſtrils is prevented by the conſtriction of the muſcles of the pharynx, together with the depreſſion of the thyreopalatinus, which manifeſtly draws the moveable velum downwards, and applies it to the tongue and pharynx, and of the circumflexus palati mollis, which ariſing a little more forwards from the ſame petrous bone, and from the ſharp proceſs of the cuneiform wing, and from the interval between the wings and innermoſt wing, and from the cartilage of the Euſtachian tube, deſcends broader; and, paſſing through the notch of the pterygoid hook, it changes its direction, and aſcends with a radiated tendon, diſperſed through the upper membrane of the velum palati, and, joining with its fellow, forms the baſis of the other muſcles, and adheres to the ſmooth edge of the palate bone. This is able both to open the tube, and depreſs the velum mobile. Thus the pharynx being contracted like a ſphincter, forces down the food, without permitting any part to regurgitate into the nares. Hence, when the velum of the palate is injured, the aliments regurgitate into the noſtrils, and deafneſs enſues.

DCXVI. During the effort to depreſs the food (DCXVII.) the velum being placed upon it, and depreſſed, is drawn down towards the tongue by the palatopharyngei, and by the circumflexus palati mollis. Theſe muſcles, together with the gloſſopalatinus,

ſopalatinus, (which laſt is indeed weak, is received into the leſſer arch of the fauces, and on the one ſide is united with its companion into an arch in the velum of the palate, and on the other is inſerted into the tongue,) preſs the velum againſt the protuberant root of the tongue, and intercept any return to the mouth. After the danger of any part falling into the windpipe is over, the epiglottis is raiſed up again, both by its own elaſticity, and by the tongue itſelf being again drawn forwards. Laſtly, the depreſſed uvula is raiſed by the azygos, which ariſes from the tendons of the circumflexus, and by the levator of the ſoft palate.

DCXVII. A little after this, follows an effort to urge the food downwards, which is exerted by the conſtrictors of the pharynx, which draw the back part forwards; theſe muſcles are partly tranſverſe, and partly aſcend into the poſterior ſurface of the pharynx. The principal is the pterygopharyngeus, ariſing from the whole hook, and from the edge of the internal wing, and from the tendon of the circumflex muſcle; from whence forming an arch, it is extended upwards and backwards, and, largely ſurrounding the upper part of the pharynx, it unites with its cognominal companion. The mylopharyngeus is partly continuous with the fibres of the buccinator, in the middle betwixt its two adheſions to the bones, and partly ariſes from an origin of its own, above the laſt of the grinders in the lower jaw. Theſe being almoſt tranſverſe, and ſurrounding the pharynx, draw its back part forwards. Next follow the aſcending muſcles in two ſtrata, the geniopharyngei, of which the obſcure and confuſed fibres originate from the tongue; the chondropharyngei, of a triangular figure, ariſing from the oſſicula triticea; the ceratopharyngei, which aſcend radiated from half of the horn; the ſyndeſmopharyngei, ariſing from the horn of the thyroid cartilage, and diſtinct from the following; the double

double thyreopharyngei, increaſed by fibres of the ſternothyroideus and cricothyroideus, and the tranſverſe, the aſcending, and the deſcending crycopharyngei. Theſe muſcles act ſucceſſively, the uppermoſt firſt, and then according to their ſituation, and force the food into the œſophagus. At the ſame time, the depreſſing muſcles of the larynx, the coracohyoideus, ſternohyoideus, and ſternothyroideus, draw down the larynx backwards, compreſs the pharynx and urge the food downwards. The arytenoidæi contract the perpendicular chink of the larynx as the food paſſes near it.

DCXVIII. As various dry and rough bodies are ſometimes ſwallowed, and as it was neceſſary for the pharynx to be dilatable and indolent, the great quantity of mucus, which is collected in all parts of the fauces, is of great importance. Therefore, in general, betwixt the nervous and innermoſt coat of the pharynx, are placed a very great number of ſimple oval follicles, which pour out through ſhort mouths a bland, aqueous, but viſcid and ropy mucus, having a greater quantity of oil, volatile ſalt and earth, than the ſaliva. They are moſt plentiful in that part of the pharynx which is extended under the occipital bone, where they are diſpoſed in a ſort of radiated right lines; and about the tonſil towards the Euſtachian tube, where commonly the ſecond tonſil lies on each ſide adjacent to the large one, and in that portion of muſcle which is called ſalpingopharyngeus. But likewiſe many flat and circular follicles of this kind are ſeated on the back part of the tongue, as far as the foramen cæcum (CCCCXLVIII.) Other pores from the pulpy fleſh of the palate, and from the numerous glands ſituated there, diſcharge a ſimilar mucus. Moreover, the whole moveable palate is of a glandular nature like the pharynx; only compoſed of more numerous and thickly diſtributed follicles. Nor,

lastly,

laſtly, are lacunæ wanting, into each of which many ſimple glands unite.

DCXIX. Where the pharynx deſcends from the pterygoidal hook betwixt the two arches of the fauces, that is between the gloſſopalatinus and pharingopalatinus, are ſeated the tonſils, one on each ſide, of an oval figure, convex behind, and thicker on the upper part, perforated inwardly with ten or more large ſinuſes, which open through the membranous velum, and by the preſſure of the adjacent muſcles diſcharge a great quantity of a very viſcid mucus from their ſinuſes. In like manner, the adjacent parts of the nares, and tumid ring of the tubes, and the ſurface of the epiglottis next to the larynx, and the back of the arytenoid cartilages, are repleniſhed with mucous organs. Laſtly, the œſophagus itſelf, on all ſides, abounds with ſimple follicles, from which a mucus more fluid is poured. The glandulæ œſophageæ are of the conglobate kind, and contribute nothing to this mucus. The blood-veſſels of the tonſils come from thoſe of the tongue and lips; thoſe of the pharynx from theſe and from the pharyngea; thoſe of the œſophagus from the pharyngeals, upper and lower thyreoidals, the bronchials and aorta. The numerous veins of the palate and tonſils, after forming plexuſes, meet in the ſuperficial branch of the internal jugular.

DCXIX. The œſophagus is a double tube, of which the interior is ſeparated from the exterior, by much inflatable cellular ſubſtance. The interior is nervous and ſtrong, continuous with the membranes of the mouth and nares, and ſeparated from the innermoſt, (which is the epidermis, plaited and porous, but not villous, exhaling a thin fluid and pulpy,) by peculiar ſhort cellular ſubſtance, in which veſſels are reticulated, and glands are interſperſed, which are continuous, and ſimilar to thoſe of the pharynx. The exterior tube, the muſcular, is alſo ſtrong,

ſtrong, with fibres continued backwards and downwards from the cricoid cartilage, changing from annular into external longitudinal fibres, raiſing the œſophagus againſt the food, and dilating it that the mouthful may be received. But other internal circular fibres, which are alſo ſtrong, ariſe in like manner from the cricoid cartilage, and by their ſucceſſive contraction, force the food down through the long tube of the œſophagus, which deſcends firſt in a direct courſe, a little to the left ſide of the windpipe; in the breaſt, it paſſes behind the heart, through the poſterior interval between the two bags of the pleura (LXXVII.) from whence it inclines by degrees a little to the right, and then forwards, that it may paſs through the appointed opening in the diaphragm (CCLXII.) in the interval between exſpiration and inſpiration. The whole œſophagus is ſurrounded externally by cellular ſubſtance, by which it is looſely tied to the neighbouring parts.

DCXX. The aliments are moved through the œſophagus as through an inteſtine. The longitudinal fibres, aſcending to the cartilages of the larynx, dilate the gullet, to receive the deſcending morſel. But when it is received into the gullet, the longitudinal fibres in like manner dilate and elevate the gullet to that place which has received it. Then that part of the œſophagus, where the morſel is ſeated, being irritated, contracts, and propels the food downwards. Its muſcularity is ſtrong, and very irritable.

DCXXI. This upper opening of the ſtomach is contracted, by the action of both the lower muſcles of the diaphragm, in inſpiration, and the food is confined within the ſtomach, ſo that every preſſure of the diaphragm ſends it naturally towards the pylorus. By this means, the ſtomach is ſo cloſely ſhut, that in perfect health, even vapours are confined

ſined within the ſtomach; and do not aſcend but from a morbid affection.

CHAP. XIX.

ACTION OF THE STOMACH ON THE FOOD.

DCXXII. THE ſtomach is a membranous bag, deſtined for the reception of the food; placed within the abdomen, behind the liver, diaphragm and left falſe ribs; of a figure ſomewhat oval, or like a caſk; longeſt tranſverſely, and the more ſo the more aged the perſon is. In the fœtus, it is altogether round and ſhort. But if we conſider its figure more accurately, every ſection of it is circular; but ſo, that, in its left extremity, there is an an impervious cavity obtuſely conical, from whence the ſtomach gradually grows wider, and its ſections increaſe towards the œſophagus, at whoſe inſertion is its largeſt ſection; from thence it diminiſhes ſlowly, till being reflected towards itſelf, it ends in the pylorus. Its bulk depends in a great meaſure on the quantity of food, by which the cavity of the ſtomach is augmented; and, on the contrary, it is diminiſhed by faſting. Its ſituation in general is tranſverſe; yet ſo that the entrance of the œſophagus is poſterior, and its right termination anterior. The middle of the human body, or enſiform cartilage, correſponds nearly to the centre of the ſtomach; but alſo to its right ſide, and laſtly to the pylorus: to the latter the umbilical fiſſure correſponds. Since its figure is round, but incurvated; when empty, its larger convex arch is pendulous; but when full, it appears prominent forwards within the peritonæum. At that time, the leſſer arch, interpoſed between the two orifices, is directed perfectly backwards, and includes the

ſmall lobe of the liver. The inſertion of the œſophagus in the full ſtomach is more horizontal; but in the empty ſtomach, more perpendicular: the right extremity of the ſtomach, when empty, is bent upwards to the pylorus; in the full ſtomach, it is bent backwards, and therefore deſcends in perſons lying on their back. In man, when alive, the ſituation of the ſtomach, approaches nearer to that which we have attributed to the full one.

DCXXIII. The viſcera, contiguous to the ſtomach, are the ſpleen, contiguous to its left imperforated extremity, and connected with it by much omentum; the lobule of Spigelius, filling up its leſſer curvature; the left lobe of the liver, largely interpoſing itſelf betwixt the ſtomach and the diaphragm, and compreſſing the anterior part of the ſtomach; after which, below the liver, a moderate portion of the ſtomach is immediately contiguous to the diaphragm, which there lies under the falſe ribs, or it is entirely covered: behind, the pancreas lies under it; below it when empty, the tranſverſe portion of the colon is contiguous for a conſiderable way; laſtly, from the leſſer curvature, ariſes the little omentum, from which a continuous, but ſtronger membrane, connects the œſophagus with the diaphragm: and the larger omentum is not connected to the whole length of the ſtomach, but is wanting on the right ſide near the pylorus; and on the left, it is continued, into a ligament, which connects the ſpleen and alſo the diaphragm with the ſtomach. The ligaments are productions of the peritonæum, receding from the diaphragm, thrown over the ſtomach, and forming is outermoſt coat. Of the orifices, the pylorus lies farther forwards, more to the right ſide, and a little lower.

DCXXIV. The fabric of the ſtomach, in general, is the ſame with that of the œſophagus; of which, it is a kind of expanſion; and, in ſome animals, perfectly ſimilar. The outermoſt coat is from the peritonæum;

peritonæum; is ſtrong, limits the reſt, and affords ſupport to the ſubjacent muſcular fibres: it is expanded into both omentums; and in that place, the ſtomach is without its outermoſt coat. Then follows the firſt cellular coat, more abundant at the origin of the little omentum, where it contains conglobate and lymphatic glands, and alſo in the region of the great omentum; it is thinner and ſhorter in the intermediate planes, ſo that the outer and muſcular tunic in them cohere together: in this ſubſtance, the large branches of the veſſels are diſtributed.

DCXXV. The muſcular coat is next in order, which is complex and difficult to deſcribe or prepare. The longitudinal fibres of the œſophagus, when they arrive at the ſtomach, diſtribute themſelves along all the ſides of the ſtomach. Some of them, of conſiderable ſtrength, run on to the pylorus, along the ſmaller curvature; part of which, by degrees declining, and following the length of the ſtomach, deſcend into the planes of each ſide, and part of them proceed along the pylorus into the duodenum itſelf, and gradually diſappear. Other ſimilar fibres, which are leſs ſtrong, deſcend to the blind ſack on the left ſide of the ſtomach. Beſides, other fibres ſurround that blind ſack, which being gradually increaſed, are continued with the circular fibres of the reſt of the ſtomach. This ſecond ſtratum of fibres is the moſt conſiderable. Laſtly, the ſphincter of the œſophagus, is the moſt internal, and is a continuation of the annular fibres of the œſophagus. It is compoſed of fibres, ariſing from the left of the œſophagus, and running to the right, on each ſide of the gullet, which they nearly ſurround; and gradually becoming longitudinal, they terminate, covered by the ſecond ſtratum, near the pylorus. The ligaments of the pylorus are two bands, lying betwixt the two curvatures, which contract the pylorus. They are formed of longi-

tudinal fibres, and run from the ſtomach to the pylorus, intimately connected with the external membrane.

DCXXVI. Next to the muſcular fibres, there is the ſecond cellular coat, larger than the firſt, eaſily inflatable, ſofter, and conſiſting of larger cells than is common in the inteſtines. Into it, the veſſels, which perforate the muſcular coat, enter with large trunks, and are divided into an angular network. Under this, lies the nervous coat, which is thick, white, and firm; and, like other nervous coats, properly conſtitutes the true ſubſtance of the ſtomach. Then the third cellular ſtratum, which is ſufficiently evident, and whoſe vaſcular network is compoſed of ſmaller veſſels than the former reticulation. Then the villous coat, continuous with the external cuticle, reparable; mucous and ſoft, with very ſhort villi, but folded into large wrinkles, ſtellated under the œſophagus, and in the middle of the ſtomach almoſt parallel with the ſtomach itſelf. But, at the extremity of the pylorus, there is a more conſiderable fold, commonly called its valve, formed of tranſverſe fibres, and of a reduplication of the nervous coat thickened, and of the villous, ſo that a kind of tumid ring is produced, ſlippery and fleſhy, which is ſurrounded by the duodenum for a conſiderable length. The large wrinkles of the villous membrane are finally ſubdivided into ſmaller ones, reſembling a reticulation, of a quadrangular figure, ſhallow, eaſily diſappearing, and more obſcure than thoſe in the biliary ducts. Throughout the whole of this villous coat, but more eſpecially towards the pylorus, I have certainly obſerved ſome pores, not always to be perceived, which terminate in ſimple follicles, ſeated in the third cellular ſtratum.

DCXXVII. The veſſels of the ſtomach are numerous, and derived from many trunks, that the afflux of the blood might not be intercepted by any preſſure,

ſure, which might eaſily have happened if there had been a ſingle trunk. The common ſource of all theſe is the cœliaca; from its tripod, or above the ſaid diviſion, ariſes its firſt and largeſt artery, the upper coronary, with one branch ſurrounding the œſophagus; to which, and to the diaphragm, and alſo to the liver, it gives branches; with another following the ſmaller curvature, it inoſculates, by an anterior and poſterior trunk, with the leſſer coronary on the right ſide, which ariſes from the right branch of the cœliac in the vena portarum itſelf, and returns along the ſmaller curvature. But the ſame right branch of the cœliac, after deſcending behind the origin of the duodenum, gives off a conſiderable artery to the great arch of the ſtomach, the right gaſtro-epiploica, which being ſuſpended in the omentum, ſupplies both ſurfaces of the ſtomach, and ſurrounding the greater part of it, it is inſerted into the left gaſtro-epiploica. Namely, the left trunk of the cœliac, as it paſſes along the duct of the pancreas and ſinuoſity of the ſpleen, ſucceſſively ſends off many branches to the ſtomach: of which the firſt are commonly nameleſs; and of the following, one branch, called the left gaſtro-epiploica, ſends off one conſiderable branch, and other ſmaller branches, to the omentum, and returns round the ſtomach to the right ſide, to inoſculate with its companion of the right ſide. Other ſmaller twigs, coming from thoſe of the ſpleen, are ſpread upon the remaining part of the greater curve of the ſtomach, as far as the diaphragm, and are called the vaſa brevia. Frequently, alſo, one or two arteries come from the ſplenic one, to the poſterior ſurface of the ſtomach under the œſophagus, in a different direction from the gaſtro-epiploics. The other arteries are ſmaller, the upper pylorics from the hepatics, and the lower from the gaſtro-epiploics, and thoſe of the loweſt part of the œſophagus from the phrenic arteries.

DCXXVIII. Thofe arteries are diftributed in the following manner: the external and mufcular membranes receive fhort branches; the trunks are arranged in the firft cellular ftratum, and with little diminution penetrate the mufcular coat; and between that and the nervous membrane, they compofe a larger and true network; in which all the fmall arteries of the different trunks are united, by an infinity of inofculations. From this reticulation, again, other fhort, but numerous and fmall ramifications, go to the third cellular and villous coat of the ftomach.

DCXXIX. The branches of the veins accompany the arteries. The greater coronary generally goes to the left trunk of the porta, together with the brevia and left gaftro-epiploic; while the right vein of the fame denomination joins with the middle vena colica, and is inferted along with it into the mefenteric branch of the vena portarum. Finally, the right coronary vein belongs to the trunk of the vena portarum itfelf. All thefe veins are without valves; and the upper coronary veins inofculate with the branches of the vena fine pari, in like manner as the arteries inofculate with the thoracic œfophagei.

DCXXX. The nerves of the ftomach are large and numerous, produced from the eighth pair, which forms two plexufes on the œfophagus, of which the anterior and fmaller goes from the œfophagus to the greater curvature and anterior furface; and the pofterior and larger to the fmaller curvature, and along with the arteries to the liver, and to the pancreas and diaphragm itfelf. Thefe nerves may be traced into the fecond cellular ftratum. Beyond this, efpecially the papillæ, are more obfcure. From their very great number, the ftomach is extremely fenfible, efpecially about the entrance of the gullet, infomuch, that acrimonies, which are not perceived by the tongue, turn the ftomach; the inteftines are

alſo known, by certain morbid obſervations, to be much more indolent; even the naked ſkin itſelf is leſs ſenſible than the ſtomach. By making a ligature upon the nerves of the eighth pair, the action of the ſtomach and the digeſtion of food are deſtroyed.

DCXXXI. I have ſeen conſiderable lymphatic veſſels in the ſmaller curvature of the ſtomach, ariſing from its glands, and inſerted by a very large trunk into the thoracic duct. Others, without doubt, ariſe from the glands of the ſame kind in the greater curve; and eminent anatomiſts have obſerved lymphatic glands over the whole ſtomach. Other lacteal veſſels, I have not ſeen, and will not readily admit thoſe lately deſcribed, which are ſaid to paſs from the ſtomach through the omentum to the liver, filled with true chyle.

DCXXXII. All bags in man are perforated by inorganic pores: through theſe, water poured into the ſtomach exudes through it when ſhut, and, on the contrary, penetrates into the cavity of the ſtomach when put under water. But we cannot for this reaſon conclude, that during life this paſſage is pervious to moiſture.

DCXXXIII. Within the human ſtomach, we firſt meet with a great quantity of mucus, anointing its villous coat, derived from the pores before deſcribed (DCXXVI.) which mucus is not unfrequently tinged by regurgitated bile. Beſides, from the ſtomach, after faſting, upon bending the body, a limpid humour will frequently flow, poſſeſſing all the properties of the ſaliva, but more mucous, which it is very difficult to obtain pure in the ſtomach. It is entirely without any acidity, when it can be had unmixed with food. When ſeparated from the acid impregnations of the food, and left to itſelf, it changes, both in man and brutes, rather to an alkaline nature, more eſpecially in a faſting animal. This liquor diſtils from the arteries of the ſtomach, through

through its villous coat, as is proved by anatomical injections; by which water, glue, and oil, may be thrown into the ſtomach, through numberleſs pores.

DCXXXIV. Then it muſt be remembered, that the ſtomach is compreſſed as in a preſs in the abdomen, which is perfectly full, between the diaphragm, of which the concave left wing lies before and above the liver, and therefore over the ſtomach, and the reſiſting muſcles of the abdomen, the rectus and obliqui, but chiefly the tranſverſe. The more the ſtomach is filled, the more it experiences this preſſure of the abdominal muſcles; becauſe, at that time, it is in contact with the peritonæum at a right angle.

DCXXXV. Now we muſt explain what is received into the ſtomach, and why it is received. The Creator has given to man pain (DLXIV.) and pleaſure, for his preſervation; the one to incite him to avoid evil, the other to invite him to uſeful actions. But the taking of aliment is of the greateſt neceſſity to man. For ſince every day there is much perſpired, much waſted of his real ſubſtance, he alſo ſtands in need of reparation; as the body is manifeſtly waſted by faſting. But the neceſſity of taking food is promoted by the natural tendency of the blood to an alkaline diſpoſition, making it always approach more nearly to a putrid acrimony, by the natural and neceſſary motions of the heart and arteries, and by the heat which very much promotes the putrefaction of animal humours. Moreover, the coagulable diſpoſition of the blood, continually loſing a great part of its water by inſenſible perſpiration, requires a ſupply of its aqueous element to ſeparate the globules and prevent it from coagulation.

DCXXXVI. Theſe truths are proved not only from their cauſes, but likewiſe by the appearances exhibited in men and other animals killed by hunger. For it is common for theſe to have an acrid fetid breath,

for their teeth to become looſe from the ſaline acrimony corroding them, and to ſuffer violent pains in the ſtomach, acute fever, and actual madneſs. Theſe diſorders are the more rapid in their progreſs, the more violently the body is exerciſed, and the more robuſt and younger it is. They enſue very ſlowly in people who are phlegmatic and unactive, who perſpire little, and whoſe blood circulates feebly. Finally, thoſe who have lived without food, have alſo lived without bodily exerciſe, and for the moſt part laboured under a diſeaſe of the nerves.

DCXXXVII. The freſh chyle, compoſed, for the moſt part, of the aceſcent claſs of vegetables, and always thinner than the blood, being received into the circulation, temperates its putreſcent acrimony, dilutes its impending coagulation, and reduces the whole maſs to that moderate degree of ſaltneſs which is natural to man: and finally, the chyle, but more eſpecially that derived from the fleſh of animals, and from the farinaceous grains, furniſhes a new gelatinous lymph, which being applied by proper cauſes (DCCCCLIX.) to the vacuities of the waſted ſolids, repairs that waſte. The drink dilutes the coagulable blood, and hinders its putrefaction, by ſeparating its putreſcent particles. Hence a perſon may live for a long time without food, if ſupplied with drink; but without drink, life ſubſiſts but a few days.

DCXXXVIII. We are induced to take food, both from the ſenſe of pain which we call hunger, and from that of the pleaſure imparted by the ſenſe of taſte (CCCCLV.) The firſt of theſe proceeds undoubtedly from the folds of the ſtomach, which poſſeſs great ſenſibility, being rubbed againſt each other, by the periſtaltic motion, and by the preſſure of the diaphragm and abdominal muſcles, ſo that naked nerves being rubbed againſt naked nerves excite an intolerable degree of pain. Thus man

is

is both effectually admoniſhed of the dangers of abſtinence, and excited to procure food by his labours. It is perhaps increaſed by the gaſtric juice having become more acrid, unleſs it putrefies.

DCXXXIX. Thirſt is ſeated in the tongue, fauces, œſophagus, and ſtomach. For whenever theſe parts, which are very ſenſible, and naturally are moiſtened by their mucous and ſalival juices, grow dry from a deficiency in the ſecretion of thoſe humours, or from muriatic or alkaleſcent ſalts adhering to them, a much more intolerable ſenſation is produced, as thirſt is attended by much greater danger, and does not abate until the abundance of water, being reſtored to the blood, and the obſtruction removed from the ſecreting veſſels in the parts mentioned, they are again moiſtened. From hence we learn, why thirſt attends labour, which exhales the water by perſpiration; and why it is a ſymptom of fevers, where the exhaling veſſels belonging to the tongue and fauces are obſtructed; why ſimple water is leſs efficacious in allaying thirſt; why ſubacid liquors are more efficacious, which not only moiſten by their fluidity, but alſo, by a mild irritation of the tongue and mouth, excite a flow of the retained humours, and at the ſame time correct putreſcency.

DCXL. From theſe cauſes, mankind being compelled to take food, has in all ages ſelected theſe ſupports of life from the vegetable and animal kingdoms, ſo that of the third, water and ſalt alone are added. It is probable, that the original choice of our foods was made by experiments, as ſuggeſted by the ſmell and flavour of certain vegetables, and as their utility was confirmed by the renewal of ſtrength. By degrees, as animals became incommodious to huſbandmen, and vegetables alone were not ſufficient for ſupporting them under their labours, the fleſh of animals was afterwards added. At preſent, the number of ſubſtances is almoſt infinite,

infinite, which we take either as food or ſeaſoning.

DCXLI. Although there are inſtances of particular perſons, and even of nations, who have lived entirely upon food taken from one claſs, as upon vegetables alone, or animals alone, and ſometimes upon a few individuals of one claſs; and laſtly, upon milk alone or its whey; yet it ſeems to be neceſſary, both from the nature of the human body, and to be indiſpenſable according to certain experiments, that we ought to ſupport life eſpecially by two kinds of food, ſo intermixed, that neither may exceed; which mediocrity we are taught from the loathing itſelf, which is excited by any one kind of food that has been continued too long.

DCXLII. The fleſh of animals appears neceſſary, from the teeth in both jaws, and from the fabric of the human ſtomach itſelf reſembling that of carnivorous animals; from the ſmallneſs and ſhortneſs of the inteſtinum cæcum, and from the ſtrength which we require. For the fleſh of animals alone contains the gelatinous lymph ready prepared, which, being extracted from the broken veſſels, paſſes eaſily and in great abundance into the blood. Abſtinence from animal food cauſes great weakneſs both in the body and ſtomach, and is uſually attended by a troubleſome diarrhœa. Man agrees with the herbivorous animals in the ſize and length of the large inteſtines.

DCXLIII. Eſculent vegetables are generally of the aceſcent kind; a few of them only are either alkaleſcent or aromatic. Few of them have that gluten which is ſpontaneouſly changeable into blood, and they only nouriſh by means of their farina, a ſmall part of which, after repeated circulations, is at laſt converted into the natural juices. Yet they are neceſſary to avoid over repletion with blood, and of too putreſcent a kind, from the uſe of animal food alone, ſuch as moſt certainly occurs in the anthropophagi,

pophagi, and produces ſcurvy, ferocity, fetor, leproſy, and every kind of alkaline corruption, all which evils are cured by change of diet, and the excluſive uſe of acid vegetables. Hence we are furniſhed with few canine teeth; and our appetite in health, but more eſpecially in diſeaſe, is ſtronger for acidulous vegetables, in proportion to the warmth of our temperament, of the ſeaſon of the year, and of the country. Hence, in the hotteſt climates, people live almoſt altogether upon vegetables, and uſe fleſh very rarely, and with danger; while, in the colder countries, it is eaten freely with leſs danger. Hence bread, or a farinaceous aliment ſimilar to it, is eaten in every part of the world.

DCXLIV. The beſt drink is pure water, free from every kind of ſalt, and not impregnated with air, which excites fermentations. That from a mountainous ſpring, which runs through a ſandy bed, and is cold, clear, light, and inſipid, is juſtly preferred. Whenever there is a deficiency of pure water, as is frequently the caſe in flat countries, or when any power ſtimulating the ſtomach to contraction, or any aromatic is required, it is ſupplied by vinous liquors, eſpecially thoſe prepared from grapes, but alſo from apples and pears; which, after fermentation, become clear, and contain alcohol and an acid ſalt diluted with water. Liquors of the ſame kind, not deſtitute of alcohol, but more flatulent, vapid and colder, are prepared by fermentation from grain toaſted, and boiled in water, in thoſe countries where the grape does not ripen.

DCXLV. Men have invented various condiments. They have added ſalt, vinegar, and acids of various kinds, to correct the putreſcence of fleſh; pepper, hot ſpices, and alliaceous ſubſtances, to ſtrengthen the ſtomach, which is weakend by the conſtant uſe of vegetables; and ſugar, ſalt and aromatics, for the ſake of flavouring or preſerving our food.

But

But none of thefe nourifh, being deftitute of gelatinous lymph, and nourifhing farina. The fpirits of wine and of corn may be of fome ufe as medicines, but are unfit for drinking.

DCXLVI. According to the difference of country, climate, or feafon, the aliments undergo various preparations, by which crudity is removed, folid fibres foftened, exceffive air expelled, difagreeable acrimony diminifhed, or a pleafant flavour imparted. But many vegetable foods, and more efpecially flefh meats, require fome trituration, particularly in man, whofe ftomach is but little flefhy, nor ought the articles of food to become putrid by remaining too long in the ftomach.

DCXLVII. The meafure of our food is determined by the ceafing of our hunger, which is different according to the difference of aliments. Animal and farinaceous food nourifhes moft : other aliments ought to fupply by their quantity, what they want in powers of nourifhment. In general, we are nourifhed beft by a fomewhat fpare diet, unlefs fubjected to much labour.

DCXLVIII. Into the ftomach, therefore, the aliments are let down, often almoft crude, and little chewed; of various kinds, as alkalefcent flefh, rancefcent fat, or acefcent vegetables, bread and milk, and glutinous fubftances. Here they are digefted in an heat equal to that of incubation, imparted by the contiguous heart, liver, and fpleen; and in a cavity fhut above (DCXXI.) and alfo below by the afcent of the pylorus, the narrownefs of the valve placed there, and the action of the fibres, conftricting the pylorus, fo that even milk itfelf remains entirely in the ftomach of healthy animals feveral hours after meals, without paffing into the inteftines. Befides, the aliments are macerated in a moift place with much air, either fwallowed during deglutition, or mixed with the aliments. This air, therefore, expanding by the force of heat, putrefaction, or fermentation,

mentation, burſts the cells in which it is included, divides the viſcid liquors, weakens the ſolid fibres, prepares ſpace for the fluid which is to enter into them. But this air alſo, which is the principal cement of animal ſolids, emerges from their ſubſtance, and leaves the other elements without a vinculum, as we ſee from the phenomena in Papin's digeſter, in the ſtomachs of animals, and even in that of man. This air, ſet at liberty, diſtends the ſtomach more than the food itſelf, and is termed flatus. At the ſame time, the aliments begin to corrupt into a nauſeous liquid, often aceſcent; at other times putreſcent, but leſs ſo in man from the influence of bread and ſalt; or ranceſcent, as appears from the flatus and eructations, variouſly fetid, and even inflammable. This is the ſole cauſe of digeſtion in fiſh and ſerpents, and almoſt in carnivorous birds. Hence, in man, metals themſelves, by long ſtay in the ſtomach, grow ſoft, and are eroded. At the ſame time hunger is removed, the nervous folds of the ſtomach being removed from mutual contact by the aliments interpoſed, the acrid gaſtric fluid being neutralized, and perhaps from the very preſence of this nauſeous liquid being diſagreeable to the nerves.

DCXLIX. But they are prevented from degenerating into complete acidity, by the heat inducing putrefaction, by the action of the gaſtric juice, and of the ſaliva, which is ſwallowed to the amount of half an ounce in an hour, both inclined to alkaleſcency, and by the bile which certainly regurgitates frequently into the ſtomach. Theſe fluids, being incorporated with the aliment, macerate and ſoften it, divide the membranes, reſolve the cellular bands, liquefy the pulps, as warm water and time do in other ſituations, extract their juice, and mingle it with themſelves. There is, therefore, no kind of fermentation in the ſtomach, from which the nature of the fluid, and the deſign of nature, are

are diſtinct. And yet the juice of the ſtomach alone, by a continuance of its action, in fiſhes, diſſolves the bones which they devour.

DCL. For, the fleſhy fibres in the ſtomach being now irritated by the flatus, weight, and acrimony of the food, begin to contract themſelves more powerfully than when the ſtomach is empty, and with greater force in proportion as it is more full, its round ſwelling ſtretching the fibres. And, firſt, the plane of the ſmaller curvature draws the pylorus to the œſophagus; and, being inſerted only into its left ſurface, it draws that to the right. The principal ſtratum of the circular fibres, diminiſhes the cavity of the ſtomach, incorporates the aliments with the juices, (DCXXXIII.) and compreſſes them ſlightly as if between the hands on oppoſite ſides and gradually determines them towards the pylorus: but it is not immediately permitted to eſcape, both on account of the reaſon before aſſigned, (DCXXVI.) and alſo becauſe this motion begins from the part that is moſt irritated; and, therefore, impels the aliment upwards, as at other times it forces it downwards. The contracted portion of the ſtomach propels the food into the neighbouring dilated part, and is in its turn relaxed when that other is contracted. Theſe alternate contractions at laſt terminate in complete evacuation. In this action, there is nothing which reſembles the trituration made by the ſtrong gizzards of granivorous fowls, which ſome anatomiſts have aſcribed to the human ſtomach; yet it has a conſiderable degree of ſtrength, and affords an example of fibres contracted to more than a third part of their length; for the ſtomach is frequently reduced to much leſs than a third of its diameter, even to the breadth of an inch; and, laſtly, is capable of diſcharging needles. Yet it neither bruiſes berries, nor the ſofteſt worms.

DCLI. The action exerted by the diaphragm and muſcles of the abdomen, is ſtronger than the periſtaltic force of the ſtomach; for, by this, it is capable

pable of perfectly evacuating the ſtomach, and of bringing its anterior and poſterior ſides into actual contact. For this force, principally, expels the fluids immediately, but the ſolids only when they are ſoftened, and rendered ſmall enough for the valve of the pylorus, through that pylorus into the duodenum, which is inclined when the ſtomach is full; for the aliments do not ſeem to leave the ſtomach, before they have loſt their fibrous or other texture, and are reſolved into a mucous, yellowiſh, cineritious, ſomewhat fetid, pultaceous liquid. That which is firſt prepared and liquefied, goes firſt, and, therefore, water and milk, firſt of all; then pot herbs; and, laſtly, fleſh. The harder, tougher, and longer ſkins or fibres, paſs at the ſame time unchanged: and ſuch things as are hard and too large to paſs the pylorus, are retained in the ſtomach for a long time.

DCLII. But the moſt conſiderable portion of the drink is abſorbed by the pendulous patulent veins of the ſtomach itſelf, correſponding to the exhaling arteries (DCXXXIII.) and is carried by a ſhorter way to the blood, as plainly appears from injections. Does any thing enter the lymphatic veſſels (DCXXXI.)?

DCLIII. The ſtomach, being irritated by too great a quantity or acrimony of the food, or elſe by nauſea from regurgitation of the bile, or other cauſe, with an antiperiſtaltic motion repels its contents upwards, and diſcharges them through the open and relaxed œſophagus, by vomiting. But this is aſſiſted by the action of the abdominal muſcles, which compreſs the belly, draw in the ribs, and, as the deſcending diaphragm acts againſt them, they evacuate the ſtomach with very great force, ſqueezed as if in a preſs.

DCLIV. But the aliments tranſmitted in their natural courſe to the duodenum, meet there with the bile which frequently regurgitates into the ſtomach itſelf, and with the pancreatic juice. The nature

of

of the former of theſe, the principal fluid of digeſtion, requires a previous hiſtory of the viſcera, which tranſmit their blood to the vena portarum.

CHAP. XX.

THE OMENTUM.

DCLV. THE peritonæum is a ſtrong ſimple membrane, by which all the viſcera of the abdomen are ſurrounded. It has an exceedingly ſmooth, exhaling, and moiſt internal ſurface; outwardly, it is every where ſurrounded by cellular ſubſtance; which, towards the kidneys, is very looſe and very fat; but is extremely ſhort at the lower tendon of the tranſverſe muſcles. It begins from the diaphragm, which it completely lines; and at the laſt fleſhy fibres of the ribs, and the external lumbar fibres, it completes the ſeptum, in conjunction with the pleura, with which it is continuous through the various intervals of the diaphragm. It deſcends behind, before the kidneys; before, behind the abdominal muſcles; it dips into the pelvis; from the bones of the pubes, paſſes over the bladder, and deſcends behind it; and being again carried backwards at the entrance of the ureters in two lunar folds, it rejoins upon the inteſtinum rectum, that part of itſelf which inveſts the loins, and in this ſituation lies before the rectum.

DCLVI. The cellular texture, which covers the peritonæum on the outſide, is continued into ſheaths in very many places; of which one receives the teſticle, on each ſide; another the iliac veſſels; others the inteſtinum rectum, the large veſſels of the pelvis, the obturatoria, penis, bladder, and aorta, and aſcending into the breaſt, accompany the gullet and vertebræ; by means of which, there is a commu-

nication between the whole body and the peritonæum, well known in dropſical people.

DCLVII. It has various prolongations for covering the viſcera. The ſhorter productions of this membrane are called ligaments; and are formed by a continuous reduplication of the peritonæum, receding from its inner ſurface, incloſing cellular ſubſtance, and extending to ſome viſcus, where its plates ſeparate; and having diverged, embrace the viſcus; but the intermediate cellular ſubſtance always accompanies this membranous coat, and joins it with the true ſubſtance of the viſcus. Of this ſhort kind of production, three belong to the liver, one or two to the ſpleen, and others to the kidneys and to the ſides of the uterus and vagina. By this means, the tender ſubſtance of the viſcera is defended from injury by any motion or concuſſion, and their whole maſs is prevented from being miſplaced by their own weight, and from injuring themſelves, being ſecurely connected with the firm ſides of the peritonæum.

DCLVIII. But the moſt important of all theſe productions of the peritonæum, are thoſe called the meſentery and meſocolon; and the deſcription of which, although very difficult, ought not to be ſeparated. We ſhall, therefore, begin firſt with the meſocolon, as being the moſt ſimple. In the pelvis, the peritonæum ſpreads itſelf ſhortly before the rectum. But where that inteſtine becomes looſe, and forms the ſemilunar curve, the peritonæum there riſes conſiderably from the middle iliac veſſels and region of the pſoas muſcle, double (DCLVII.) and with a figure adapted for receiving the hollow colon. But above, on the left ſide, the colon is connected with almoſt no intermediate looſe production to the peritonæum, ſpread upon the pſoas muſcle, as high as the ſpleen, where this part of the peritonæum, which gave a coat to the colon, being extended under the ſpleen, receives

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and ſuſtains that viſcus, in a hollow ſuperior receſs.

DCLIX. Afterwards the peritonæum, from the left kidney, from the interval between the kidneys, from the large veſſels, and from the right kidney, emerges forwards, under the pancreas; and forms the broad and ſufficiently long continuous production, called the tranſverſe meſocolon, which, like a partition, divides the upper part of the abdomen, containing the ſtomach, liver, ſpleen, and pancreas, from the lower part. The lower plate of this tranſverſe production, is continued ſingly from the right meſocolon to the left, and ſerves as an external coat to a pretty large portion of the lower and deſcending part of the duodenum. But the upper plate, leſs ſimple in its courſe, departs from the lumbar peritonæum at the kidney and region of the vena cava, farther to the right than the duodenum, to which it gives an external membrane, not quite to the valve of the pylorus; and, beyond this inteſtine, and beyond the colon, it is joined with the lower plate, ſo that a large part of the duodenum lies within the cavity of the meſocolon. Afterwards, in the region of the liver, the meſocolon is inflected, and deſcending over the kidney of the ſame ſide, much ſhorter, it includes the right of the colon, as far as the inteſtinum cæcum, which reſts upon the iliac muſcle, and the appendix, which is provided with a peculiar, long, curved meſentery. There the meſocolon terminates, almoſt at the bifurcation of the aorta.

DCLX. The whole of the meſocolon, and of the meſentery, is hollow; ſo that air may be forced in between its two ſimilar plates, in ſuch a manner as to expand it into a bag. At the place where it ſuſtains the colon, and alſo from part of the inteſtinum rectum, the meſocolon, continuous with the outer membrane of the inteſtine, forms itſelf into ſmall ſlender bags, reſembling the omentum, for the moſt

part in pairs, with their looſe extremities thicker and bifid, and capable of admitting air, blown in between the plates of the meſocolon.

DCLXI. In the next place, we come to the meſentery, a very large, folded production of the peritonæum, continuous with the tranſverſe and right meſocolon, at the right ſide of the emerging duodenum; and then proceeding for a long way with both meſocolons, even as low as the pelvis. The meſentery, under the right portion of the tranſverſe meſocolon, deſcending from that part of the peritonæum, which lies upon the aorta, under the pancreas, and having numberleſs folds in its edge, contains the very long ſeries of the ſmall inteſtines.

DCLXII. Every part of the meſentery and meſocolon contains fat, collected in the neceſſary interval of the plates; generally in greater quantity, where they are longer; and interpoſed veſſels diſtributed around the fat, which the arteries ſecrete, and the veins, as already mentioned, abſorb; and alſo very numerous glands, which are moſt conſpicuous in a young ſubject.

DCLXIII. The nature of the omentum is very analogous to that of the meſentery. But there are many membranes that come under this general denomination, of the ſame ſtructure and utility, all compoſed of a tender membrane, very eaſily lacerated, through which reticulated veſſels are diſtributed, with fat depoſited in ſtreaks along their courſe. This membrane is always double; and between its lamellæ, cloſely connected by very tender cellular ſubſtance, the veſſels are diſtributed, and the fat collected. And, firſt, where the top of the right kidney, and the lobulus caudatus of the liver, with the ſubjacent large veſſels, form an angle with the duodenum, there the external membrane of the colon which comes from the peritonæum, joining with the membrane of the duodenum, which alſo ariſes immediately from the peritonæum,

tonæum lying upon the kidney, enters backwards into the tranſverſe fiſſure of the liver for a conſiderable ſpace, is continuous with its external coat, contains the gall bladder, ſupports the hepatic veſſels, and is very yellow and ſlippery. Behind this membranous production, betwixt the right lobe of the liver, hepatic veſſels, vena portarum, biliary ducts, aorta, and adjacent duodenum, there is a natural opening, by which air may be blown extenſively into all that cavity of the omentum, which we ſhall preſently deſcribe; and, laſtly, into the bags of the reſt of the omentum.

DCLXIV. From thence, in a courſe continuous with this membrane (DCLXIII.) from the pylorus and the ſmaller curvature of the ſtomach, the external membrane of the liver joins in ſuch a manner with that of the ſtomach, that the thin membrane of the liver is continued out of the foſſa of the venal duct, acroſs the little lobe, into the ſtomach, ſtretched before the lobe and before the pancreas. This is the little omentum or hepatico gaſtricum; which, when inflated, reſembles a cone; and gradually becoming harder, and emaciated, it changes into a true ligament, by which the œſophagus is connected to the diaphragm (DCXXIII.)

DCLXV. But the larger omentum, the gaſtrocolicum, is of a much greater extent. It begins at the firſt acceſſion of the right gaſtro-epiploic artery to the ſtomach, being continued there from the upper plate of the tranſverſe meſocolon (DCLIX.); and then from the whole great curve of the ſtomach, as far as the ſpleen, and alſo from the right convex end of the ſtomach towards the ſpleen, until it alſo terminates in a ligament that ties the upper and back part of the ſpleen to the ſtomach. This is the anterior lamina.

DCLXVI. Being continued downwards, ſometimes to the navel, ſometimes to the pelvis, it hangs before the inteſtines, and behind the muſcles of the abdomen,

abdomen, until, from its lower edge being reflected upon itſelf, it aſcends, leaving an intermediate vacuity between it and the anterior lamina, and is continued for a very great extent into the external membrane of the tranſverſe colon, and laſtly into the ſinus of the ſpleen, by which the large blood-veſſels are received, and it ends finally on the œſophagus, under the diaphragm. Behind the ſtomach, and before the pancreas, its cavity is continuous with that of the ſmaller omentum.

DCLXVII. To this the omentum colicum is connected, which ariſes farther to the right than the firſt origin of the omentum gaſtrocolicum from the meſocolon, with the cavity of which it is continuous, but produced ſolely from the colon and its external membrane, which departs double from the inteſtine; it is prolonged, and terminates by a conical extremity, ſometimes of longer, ſometimes of ſhorter extent, above the inteſtinum cæcum.

DCLXVIII. The uſes of the omentum are many. In common with the meſentery, it forms looſe ſpaces, into which the fat may be poured, and preſerved during ſleep and inactivity, that it may be afterwards diſſolved by increaſe of motion, reſtored by the abſorbent veins, and conſtitute a principal ingredient of the bile. Hence it is ſometimes found very thick, even an inch thick, and at others thin, and more tranſparent than paper. For that the fat returns again into the veins, is demonſtrated from human omenta being found of very different bulks and fatneſs, according as they belonged to indolent, laborious, or diſeaſed ſubjects; from the phenomena in animals; from the analogy of all the reſt of the fat of the human body (xx.); from experiments in frogs, where this reabſorption of the fat may be made evident to the eye; and, laſtly, from the evidently inflammable nature of the bile. Hither I alſo refer the diſorders of digeſtion, the crudities

and

and coldneſs of the ſtomach, obſerved from cutting out the omentum.

DCLXIX. For all the blood which returns from the omentum and meſocolon, goes into the vena portarum, and by that into the liver itſelf. The omentum gaſtrocolicum is furniſhed with blood from each of the gaſtro-epiploic arteries, by many deſcending reticulated branches: of which the moſt lateral are the longeſt, and the loweſt anaſtomoſe by minute twigs with thoſe of the colon. It alſo has branches from the ſplenic, duodenal, and adipoſe arteries. The omentum colicum has its arteries from the colon, as alſo the ſmaller appendices, (DCLX.) and from the duodenal and right epiploic. The arteries of the ſmaller omentum come from the hepatics, and from the right and left coronaries.

DCLXX. The omentum, being fat and indolent, has very ſmall nerves. They ariſe from the nerves of the eighth pair, both in the greater and in the leſſer curvatures of the ſtomach.

DCLXXI. The arteries of the meſentery are, in general, the ſame with thoſe which go to the inteſtines, and of which the ſmaller branches remain in the glands and fat of the meſentery. Various ſmall acceſſory arteries go to both meſocolons, from the intercoſtals, ſpermatics, lumbars and capſulary, to the tranſverſe portion, from the ſplenic artery and pancreatico duodenalis, and to the left meſocolon, from the branches of the aorta going to the lumbar glands.

DCLXXII. The veins of the omentum, in general, accompany the arteries, and unite into ſimilar trunks: thoſe of the left part of the gaſtrocolic omentum into the ſplenic, and alſo thoſe of the hepaticogaſtric, which likewiſe ſends its blood to the trunk of the vena portarum: thoſe from the larger and right part of the gaſtrocolic omentum, from the omentum colicum, and from the appendices epiploides, into the meſenteric trunk. All the veins of the meſentery

mefentery meet together in one, which is the true trunk of the vena portarum : being collected firft into two large branches ; of which the one, the mefenteric, receives the gaftro-epiploic vein, the colicæ mediæ, the iliocolica, and all thofe of the fmall inteftines as far as the duodenum ; the other, which going tranfverfely inferts itfelf into the former, above the origin of the duodenum, carries back the blood of the left colic veins, and thofe of the rectum, except the lowermoft, which belong partly to thofe of the bladder, and partly to the hypogaftric branches of the pelvis. The vein which is called hæmorrhoidalis interna, is fometimes inferted rather into the fplenic than into the mefenteric vein. Has the omentum alfo lymphatic veffels ? Certainly there are conglobate glands, both in the little omentum and in the gaftrocolicum ; and ancient anatomifts have obferved pellucid veffels in the omentum ; and a modern has defcribed them for lacteals of the ftomach.

DCLXXIII. The other ufes of the omentum are, to interpofe itfelf betwixt the inteftines and peritonæum, which are very apt to adhere ; to preferve the mobility of the former entire, both among themfelves and upon the peritonæum ; to leffen friction ; and to lubricate the mufcular fibres with a very bland oil. Therefore, even in infects, there is a great deal of fat around the inteftines. In the large inteftines, there are a great many appendices, becaufe they have larger lacerti, and cannot be altogether covered by the omentum. The omentum alfo arranges the veffels, conducts and fupports them, connects the contiguous vifcera, and exhales a foft vapour, which, mixing with watery abdominal exhalations, anoints and lubricates all the vifcera.

DCLXXIV. The mefentery fuftains the inteftines in fuch a manner, that they poffefs both mobility and firmnefs : it fupports and conducts with fafety the blood-veffels, lacteals and nerves ; it fixes the glands,

glands, as ſhall be noticed hereafter, gives an external coat to the inteſtines, and forms moſt of the omenta.

DCLXXV. But beſides, the blood, returning through the meſenteric and meſocolic veins, brings with it to the liver a ſecond principal conſtituent of the bile; namely, a copious ſubalkaline humour, which is abſorbed from all the ſmall inteſtines, as will be demonſtrated in its proper place. Moreover, from the large inteſtines, it conveys to the liver another fluid, but more putrid, fetid, and nearly approaching to the nature of volatile alkali, abſorbed from the alvine fæces, that now begin to ſmell ſtrong; which is eaſily proved, both from proper experiments, and from the induration of the fæces when too long retained in the bowels. For this water is naturally fluid, and rendered more ſo by incipient putrefaction; it moderates the tenacity of the oil from the omentum and meſentery, and keeps it from coagulation. But it eſpecially imparts to the bile that alkaline rancidity with which it abounds, and on which the great tenuity, and dyeing and ſaponaceous powers of the bile almoſt ſolely depend.

CHAP. XXI.

SPLEEN.

DCLXXVI. THE ſpleen is alſo one of thoſe viſcera, which ſend their blood to the liver. It is pulpy, bloody, livid, and ſomewhat thick; of an oval circumference, often notched on the margin, or even divided into lobes; on one ſide, towards the ribs, convex, on the other concave; with two ſurfaces, one anterior towards the ſtomach, and another poſterior towards the diaphragm; divided by the entrance of its veſſels; and with two extremities, of which the inferior and anterior is the ſharpeſt.

ſharpeſt. It is connected to the ſtomach by the little omentum and upper ligament, ſupported from the adjacent colon by the ligament (dclviii.) behind, it is contiguous to the renal capſule; and it is connected to the kidney by the peritonæum. It alſo receives the peritonæum from the diaphragm, under the denomination of a ligament, in the back part of its hollow ſinus, behind its veſſels. Its ſituation is variable, and depends on the ſtomach. When that is empty, the ſpleen is placed more perpendicularly, and its extremities become ſuperior and inferior: but when the ſtomach is full, and its middle curvature ariſes forwards (dcxxii.) then the ſpleen at the ſame time changes its ſituation, and its extremities become anterior and poſterior, ſo as to lie almoſt tranſverſely. Alſo, being of a very ſoft texture, it is more ſpongy and larger when the ſtomach is empty; and when the ſtomach is full, being preſſed by it againſt the ribs, it is emptied. Hence, in weak ſubjects, it is large; but in thoſe who die ſuddenly, and in full health, it is ſmall. It alſo deſcends with the diaphragm in inſpiration, and aſcends with it in exſpiration; and beſides, it frequently varies its ſituation with the colon. Frequently there is a ſecond acceſſory ſpleen, or even ſeveral.

dclxxvii. The blood-veſſels of the ſpleen are large, in proportion to its weight. The arterial trunk comes from the cœliac; the left branch of which proceeds in a ſerpentine courſe, above and behind the pancreas, to which it gives branches, and to the meſocolon, ſtomach, and omentum, incurvated along the ſulcus of the ſpleen, and being ſupported by the right end of the gaſtrocolic omentum, it in a manner perforates the ſpleen by many branches. The thickneſs of this artery is greater than that of the aorta. The ſplenic vein is remarkably ſoft, almoſt more ſo than any other vein of the body; it forms the principal left branch of the vena portarum,

portarum, and, befides the branches accompanying the arteries, it receives the great coronary, defcending behind the pancreas, and fometimes the internal hæmorrhoidal. The vafa brevia, arifing from thofe of the fpleen, we have mentioned elfewhere; and laftly, fmall twigs from the lumbars, phrenics, intercoftals, and thofe of the renal capfules, go to the ligaments and membranes. In like manner, the fplenic and fhort veins communicate with the renal capfulary, renal and phrenics.

DCLXXVIII. The lymphatic veffels which are defcribed in the duplicature of the membrane of the fpleen, which, however, does not exift, and are faid to proceed on to the receptacle of the chyle, are very evident in the calf; and in mankind are rendered confpicuous by blowing air under the membrane, or by maceration, or by injecting water into the artery.

DCLXXIX. The nerves of the fpleen are fmall; fo that it is little fufceptible of pain, and is very rarely inflamed. They arife from a particular plexus of the pofterior branches of the eighth pair, (DCXXX.) and of peculiar branches from the large gangliform plexus, which the fplenic trunk of the intercoftal nerve produces; and they furround the fplenic artery with branches.

DCLXXX. The fabric of the fpleen appears to be much more fimple than is commonly believed. For it is compofed, both in man and in calves, entirely of arteries and of veins; the former of which are remarkably branchy, and fubdivided into fewer large branches, but into very numerous minute ones, terminating finally in very tender twigs, very difficult of injection, and arifing very crowded together; from which there is a ready paffage into the correfponding veins. Various authors have confidered thefe pencils, with their parallel branches, being fomewhat round, as glands. Injection, rightly managed, never efcapes into any intervals;

nor

nor have hollow glands ever been demonſtrated with certainty. Each little arterial trunk, with the ſmaller twigs that proceed from it, is ſurrounded by a very fine cellular web, in the ſame manner as in all the viſcera, but here rather ſofter. The whole body of the ſpleen is externally ſurrounded by a ſingle membrane, ſimple and not very firm, continued from the peritonæum, and joined to the ſubſtance of the ſpleen by thicker cellular ſubſtance.

DCLXXXI. Obſervation alſo teaches us, that the ſpleen contains more blood, in proportion, than any other viſcus; ſince it has no muſcles, fat, air veſſels, or excretory ducts, interpoſed between its blood-veſſels. Its blood is ſcarcely ever coagulated, has a ſomewhat dark colour, and from its dilution, colour, and greater proportion of water, may be almoſt compared to the fœtal blood. It abounds with water and volatile ſalt, but has leſs oil.

DCLXXXII. The want of an excretory duct to the ſpleen, has occaſioned, in all ages, inquiries, doubts, and controverſies, about its uſe. The following ſeems to us to correſpond with its fabric; although, perhaps, all the uſes of the ſpleen are not comprehended by it. A great quantity of blood is carried to the ſpleen, (DCLXXVII.) and, from the denſity and ſerpentine courſe of the artery, its motion is ſlow; but, when the ſtomach is empty, at which time it arrives in greater quantity, and being leſs compreſſed, is retained in the ſpleen, it in ſome meaſure ſtagnates, from the very great proportion of branches to the trunks in this part; and the difficult circulation of the blood of the ſpleen through the ſtraits of the liver. Hence the very frequent ſchirroſities of the ſpleen; hence that immenſe quantity of blood with which the whole ſpleen is diſtended, and which is not found in any other viſcus in ſuch quantity. Therefore the blood, in this warm ſituation, and fomented by the putrid fæces of

of the adjacent colon, is refolved, and afterwards advances, in a certain degree, towards putrefaction, as appears from its colour and fluidity. But it is the more fluid, becaufe the fpleen has no fecretory veffels, and therefore the whole quantity of water enters the vein, which was brought by the artery.

DCLXXXIII. Then, when the ftomach is filled with food or flatus, the fpleen is compreffed into a narrower compafs, againft the refifting ribs and fuperincumbent diaphragm, and the blood which was returning through the fplenic vein, flowly and in fmall quantity, is fuddenly preffed out of the fpleen, returns with celerity to the liver; mixes with the fluggifh blood loaded with the fat of the omentum and mefentery, (DCLXIX.) dilutes it, preferves it from coagulation and ftagnation; and, at the fame time, it conduces to increafe the fecretion of bile, at the time when it is moft wanted, for the procefs of digeftion which is then going on. The fpleen, therefore, feems to fupply to the bile fome aqueous principle, but probably of a fubalkaline nature, and acrid from its ftagnation.

DCLXXXIV. Is the fabric of the fpleen cellular? Does the blood poured out into thofe cells ftagnate? Is it diluted with fome juice fecreted by peculiar glands? Nothing of this is demonftrated by anatomy; nor do liquids or wax ever efcape from the arteries, unlefs injected with two great violence. Is an acid juice prepared in the fpleen for the ftomach? That opinion is difcarded, as repugnant to the nature of all the animal juices, and inadmiffible, from the want of a paffage. Is the fpleen ufelefs? Is this proved, by the little injury animals fuftain from its extirpation? The lofs even of a confiderable part does not injure a robuft animal; and yet there are examples, where, from its extirpation, the liver became fwelled and difeafed, the bile more fcanty and darker, and troublefome flatulencies fucceeded, which are referable

ferable to the vitiated nature of the bile, the obſtruction of the liver, and diminiſhed powers of digeſtion; if they were confirmed by repeated experiments.

CHAP. XXII.

PANCREAS.

DCLXXXV. THE pancreatic juice, which is watery, inſipid, thin, neither acrid nor alkaline, is excreted at the ſame place into which the bile is diſcharged.

DCLXXXVI. The pancreas, the largeſt of the ſalivary glands, is of great length, is ſituated before the left renal capſule and the aorta, above the inferior lamina of the tranſverſe meſocolon; (which beyond the pancreas, behind its ſuperior lamina, behind the ſtomach, before the ſpleen, under and behind the liver, joins with the inferior lamina;) is of a flattiſh triangular ſhape, with a light depreſſion on the upper part, and is covered with the peritonæum. Upon it, being poſterior and inferior, the poſterior ſide of the empty ſtomach reſts. The pancreas begins at the ſpleen itſelf; extends almoſt tranſverſely towards the right ſide, acroſs the vertebræ, at the right of which it grows broader, being received betwixt the ſuperior and inferior plates of the tranſverſe meſocolon (DCLIX.) and is, finally, ſo connected by its round head to the duodenum, as to ſerve it for a meſentery. It is like the ſalivary glands, compoſed of round, hardiſh acini, connected by a good deal of cellular ſubſtance. Its veſſels are rather numerous than large, and are derived chiefly from the ſplenics: but on the right ſide it is ſupplied by the firſt artery of the duodenum, and from another which is inferior, and is common to the

the duodenum and pancreas; both of which ariſe from the hepatic artery, and of which the former inoſculates with the latter, and both with the meſenteric artery, which alſo ſupplies conſiderable twigs to this gland; and minute branches come from the phrenic and capſular arteries. The nerves are not conſiderable, whence it is little ſenſible; they are derived from the poſterior gaſtric, the hepatic and ſplenic plexuſes, &c.

DCLXXXVII. The duct runs through the middle of this gland, white and tender, ariſing every where from an infinite number of roots, by which, being gradually increaſed, it emerges before the vena portarum and meſenteric artery, having received a larger branch from the larger part of the pancreas; following the courſe of the duodenum, it arrives at the ſame part of the duodenum into which the biliary duct proceeds; where, changing its courſe, it deſcends, and being extended into a ſinus, betwixt the coats of the inteſtine, internally ſmooth; and, being continued, after having received the ductus choledochus, it opens in a particular fold in the bottom of the deſcending part of the duodenum. But it not unfrequently happens, that it opens by an orifice diſtinct from that of the biliary duct; and ſometimes by two, of which the one, the lower, is diſtinct and leſs; but in man, and in moſt other animals, it always opens near the biliary duct. In its orifice there is no valve.

DCLXXXVIII. The quantity of fluid ſecreted is uncertain: but it muſt be very conſiderable, if we compare it with the weight of the ſaliva, the pancreas being three times larger, and ſeated in a warmer place. It is expelled by the force of the circulating blood, and of the incumbent viſcera in the full abdomen; as the liver, ſtomach, ſpleen, meſenteric and ſplenic arteries, and the aorta. Its great utility appears from its conſtancy, being found in almoſt all animals: nor is it refuted by the

the few experiments, in which a part of it was cut out from a robuſt animal without occaſioning death; becauſe the whole pancreas cannot be removed without the duodenum: for even a part of the lungs may be cut out, without producing death, but they are not therefore uſeleſs. Its effervescence with the bile ariſes from the effect of the ligature, and of air mixed with the inteſtinal humour.

DCLXXXVIII. It ſeems principally to dilute the viſcid cyſtic bile, to mitigate its acrimony, and to mix it with the food. Hence it is poured into a place remote from the cyſtic duct as often as there is no gall bladder. Like the reſt of the inteſtinal humour, it dilutes and reſolves the maſs of aliments, and performs every other office of the ſaliva.

CHAP. XXIII.

LIVER, GALL BLADDER, AND BILE.

DCLXXXIX. THE liver, the largeſt of all the viſcera, occupies a large part of the abdomen, above the meſocolon; and in the fœtus one ſtill larger. Both above, and behind, and before, and to the right, it is covered by the diaphragm, from which it receives the peritonæum, under the denomination of ligaments, chiefly in three places. For on the convex part of the liver, from the paſſage of the vena cava to the tranſverſe furrow of the liver, the peritonæum deſcends double, growing broader anteriorly, under the name of ligamentum ſuſpenſorium, which divides the greater right lobe from the ſmaller left lobe; and diverging, it expands into a membrane of the liver, (DCXXIII.) white, ſimple, thin, like the external coat of the ſtomach, having cellular ſubſtance under it, by which it is joined to the ſub-

ſtance

ſtance of the liver. To the lower margin of this, the umbilical vein is united; which, in the adult, having almoſt diſappeared, leaves a fibrous appearance, with much fat. In the extremity of the left lobe, and on the convex part, and not unfrequently at its edge, a membrane goes to the liver from the diaphragm; which in children, and in other inſtances, is frequently to the left ſide of the œſophagus, but in adults to the right ſide; and always conjoined both to the gullet and to the ſpleen, when the liver is large. This is the left ligament. The right ligament ties the diaphragm very far back to the very thick right lobe. Beſides, but without any apparent length, the membrane of the right lobe of the liver is often conjoined with the diaphragm by cellular ſubſtance in the right lobe, behind and to the right of the oval lobule, more eſpecially in old ſubjects, for in the fœtus it is eaſily ſeparated; and betwixt the ſuſpenſory and left ligament, there intervenes a production of peritonæum, in like manner continuous, reſembling a ligament. But alſo from the kidney, the peritonæum going to the liver makes a reduplication like a ligament; and the ſmaller omentum, and the continuous looſe productions of the meſocolon (DCLXIII.) unite the liver with the ſtomach, duodenum and colon; and the meſocolon alſo unites it to the pancreas. Thus the liver is ſuſpended in the body with firmneſs, and yet with conſiderable mobility, ſo that it may be variouſly agitated and depreſſed by the diaphragm. The ſame ligaments form the common membrane, which covers the liver as well as other viſcera.

DCXC. Moreover, the inner concave ſurface of the right lobe of the liver, correſponds with its forepart to the colon; and with its back part to the right kidney and renal capſule, to which it is connected by cellular ſubſtance. The middle ſinus is contiguous to the duodenum, which touches the

 gall

gall bladder, and that part which conducts the great blood-veſſels. The left lobe extends largely over the ſtomach; and frequently, eſpecially in younger ſubjects, is extended beyond the œſophagus into the left hypochondrium. The lobule adapts itſelf to the ſmaller curvature of the ſtomach. But, moreover, the pancreas lies under the liver, and the right venal capſule is tied to the part of the liver fartheſt to the right by much cellular texture.

DCXCI. The figure of the liver is difficult to deſcribe. It begins in the cavity of the right hypochondrium, by a very thick ſolid protuberance, convex towards the diaphragm, and hollow towards the colon and kidney; having a protuberant line dividing theſe concave ſurfaces, which is continued into the longer appendix of the lobule. After this, the liver grows gradually ſlenderer and thinner, and is extenuated, with an almoſt triangular ſhape, into a tip, which paſſes into the left hypochondrium, acroſs the œſophagus, in young ſubjects, as far as the ſpleen; but in adults, it is often ſhorter, and ends at the œſophagus. The edge, in which the convex part of the liver meets with the concave one, is wholly in the anterior and lower part. The whole obtuſe margin lies backwards. The upper and back part of the liver is every where convex; ſuſtains the diaphragm; and with a large portion, which is ſomewhat flatter towards the left ſide, it lies under the heart: but the lower ſurface, variouſly figured, reſts upon the duodenum, colon, ſtomach, pancreas, and right renal capſule. For there are ſeveral fiſſures which divide the ſurface into different regions, which did not eſcape the notice of the ancients.

DCXCII. The principal of theſe, the tranſverſe, extends from right to left, and divides a third part of the liver, beginning ſlender in the right lobe, and growing broader towards the left. Before this tranſverſe fiſſure, there is an excavation in the right

lobe for the gall bladder; then there is the convex anonymous lobe; and then the foſſa of the umbilical vein, extending tranſverſely backwards, often covered with the bridge that joins the anonymous to the left lobe. Behind the great ſulcus in the right ſide, there is a tranſverſe eminence, ſlender at its commencement, growing broader towards the right and moderately hollow, by which the great blood-veſſels are conducted into the liver: the hollow was by the ancients denominated the portæ. This joins the lobe, which I ſhall next deſcribe, with the right lobe. Then the poſterior lobule, papillary, obtuſely conical, projects into the little curvature of the ſtomach. The thick root of this and of the former excavated eminence, begins from the convex part of the liver, at the diaphragm; and in the right ſide, is impreſſed with an oblique furrow, inclined to the right ſide, for the trunk of the vena cava, deſcending from the heart to the lumbar vertebræ, and frequently covered by a conſiderable portion of the ſubſtance of the liver, as by a bridge, ſo as to form a tube. The left end of the lobule is terminated by another foſſa almoſt ſtraight backwards, but alſo inclined to the left; which beginning at the extremity of the tranſverſe one, terminates at the paſſage of the vena cava through the diaphragm. In this was lodged the ductus venoſus in the fœtus, of which there are ſtill ſome remains to be perceived in the adult. All that lies beyond this is the left lobe, which is ſimple, uniformly concave below, ſo as to lie upon the ſtomach, and extenuated to an edge.

DCXCIII. This very large viſcus is proportionably ſupplied with veſſels, and of various kinds. The artery, which is indeed conſiderable, being the greater and right portion of the cæliac, emerging forwards and to the right, goes tranſverſely before the vena portarum; and after giving off the ſmall coronary and the pancreatico duodenalis, the latter

of which is pretty large, the reſt enters the liver, commonly by two branches; of which the left ſupplies the umbilical foſſa, the venal duct, poſterior lobule, with the left and the anonymous lobes, and the ſuſpenſory ligament; this branch inoſculates with the phrenic and epigaſtric arteries. The right lies deeper, covered by the biliary ducts; goes to the right and anonymous lobes, and ſends off, in one ſmall trunk, the cyſtic artery, which immediately dividing into two, is ſpread both under and over the gall bladder, covered by its external coat, and ſupplies branches to the gall bladder and biliary ducts, and likewiſe many to the liver. From the left branch, or ſometimes from the trunk, a ſuperficial artery goes to the biliary ducts, anonymous lobe, and glands of the portæ. Beſides the cæliac artery, not very rarely, a large right branch is produced from the meſenterica major, creeping behind the pancreas; this ſerves inſtead of the right hepatic branch of the cæliac. But, likewiſe, the greater coronary, which is the firſt twig of the cæliac, always gives ſome ramifications to the left lobe, and to the foſſa of the ductus venoſus; which is often very conſiderable. Thoſe ſent to the liver from the phrenic, mammaries, renal and capſulary arteries are ſmaller. They communicate alſo with the epigaſtrics.

DCXCIV. In the fœtus, the umbilical vein brings a great deal of blood to the liver, at which time the vein going to the portæ is but ſmall. It ſends forth, while it ſtretches backwards through its foſſa, numerous and very large branches, each of them equalling the vena portarum in bigneſs; at this place it is dilated into a tumor, which unites with the left branch of the vena portarum. But it ſends a ſingle branch through the poſterior part of the horizontal foſſa into the vena cava, or into ſome of its hepatic branches: this is called the ductus venoſus. In the adult, indeed, this duct is obliterated, and

and the vena portarum, which has now grown larger, ſupplies the hepatic branches.

DCXCV. The vena portarum receives all the blood of the ſtomach (DCXXIX.) of the inteſtines and meſentery (DCXXXI.) of the ſpleen (DCLXXVII.) omentum (DCLXIX.) and, laſtly, of the pancreas, at firſt into two trunks, the tranſverſe ſplenic and aſcending meſenteric, and then into one, which is continued with the meſenterics. It is large, compoſed of ſtrong membranes, ſtronger than thoſe of the vena cava, aſcends behind the firſt flexure of the duodenum, receives the veins from the right ſide of the duodenum, and the ſmaller coronary, aſcends to the right in the ſinus of the lobule of the liver (DCXCII.) and is afterwards again divided into two large trunks. The right, which is ſhorter, larger, and bifurcated, having received the cyſtic vein, goes to its own lobe. The left proceeds through the remaining part of the tranſverſe furrow of the liver, and ſupplies the lobule, the anonymous and left lobe, and being reflected, enters the umbilical foſſa, about the middle of which, it penetrates branchy into the liver. There are inſtances in which the branch of the poſterior lobule rather proceeds from the trunk of the vena portarum.

DCXCVI. The vena portarum is ſurrounded on every ſide with a good deal of cellular ſubſtance, which it brings with it from the meſentery and ſpleen; and which being denſe and ſhort, ſtrengthens the membranes, which are firmer than thoſe of the aorta itſelf. Intermixed with this cellular ſubſtance, are alſo many ſmall veſſels and the hepatic nerves, which are all comprehended under the denomination of capſule, which is nothing more than the cellular ſubſtance, and never has a ſingle truly fleſhy fibre. The vena portarum carries this along with it, through the liver, and is ſuſtained by it; inſomuch, that the branches, when cut, being ſupported, preſerve the roundneſs of their ſection.

Each

Each branch of the vena portarum is divided into many others, again divided and ſubdivided, even to the ſmalleſt capillaries, as arteries commonly are. Every branch of the vena portarum is accompanied by a branch of the hepatic artery, creeping upon its ſurface, and upon the hepatic ducts, almoſt in the ſame manner as the bronchial arteries uſually creep along the bronchia; and by a branch of the biliary duct, which are both connected by thin cellular ſubſtance. Some go out of the liver, being divided on the ligaments, and inoſculating with the ſurrounding veins. The ſum of the branches in the vena portarum is always greater than the trunk; hence the calibers of all the branches together, greatly exceed that of the trunk (XXXVII.) Hence there is a great degree of friction, (CLXXX. and CLXII.) exactly as in the arteries.

DCXCVII. But as the blood is conveyed to the liver by the vena portarum, as well as by the hepatic artery, it muſt of courſe be conveyed away by ſome other vein. Therefore, the extreme branches of the vena portarum and hepatic artery inoſculate ultimately with other veins, which are branches of the cava; ariſing from the whole circumference of the liver, they run towards the poſterior gibbous part of the liver, unite into branches and trunks, which at laſt terminate in ten or more large veſſels. The ſmaller and more numerous of theſe, ariſe from the poſterior lobule and liver, and go to the cava, where it aſcends towards the left, to the diaphragm, through the ſulcus, that lies on the right ſide of the lobule, and is often included by a bridge thrown over it. The remaining two or three, which are much larger, are inſerted into the ſame cava, cloſe to the diaphragm, whoſe veins they often receive. The branches of the vena cava are, in the adult, on the whole, fewer than thoſe of the vena portarum; which is an argument that the blood moves more quickly through theſe branches, on account of the

diminution

diminution of the friction, (CLXX.) and of the very collection of the blood into a lefs caliber, which always accelerates its courfe, when there is a fufficient compreffing force (CLXX.) I know not of any valves in the mouth of thefe veins, which deferve to be remembered. The trunk of the vena cava afcends through a foramen of the diaphragm, obtufely quadrangular, included by mere tendons furrounding it; and therefore (CCLXII.) not eafily variable: and immediately expands into the right auricle. The fmaller veins of the liver, creeping upon its furface, are fent from the phrenica, renalis and azygos; or at leaft there is a communication betwixt thefe and the hepatic veins coming from the portæ.

DCXCVIII. That the blood comes from all parts (DCXCV.) by the vena portarum to the portæ, is proved by ligatures, by which the veins fwell betwixt thefe parts and the ligatures; while the vena portarum itfelf grows flaccid and empty. But that it afterwards goes through the liver to the cava, is proved by anatomical injections, which fhow the anaftomofes, and open communication betwixt the vena portarum and the cava, and by the common nature of the veins going to the cava. Again, the difficulty of the arterial diftribution of the vena portarum, as being remote from the heart, and the oily nature of its blood, occafion it to ftagnate, accumulate and form fcirrhous fwellings in the liver oftener than in any other part. But this danger is diminifhed by mufcular action, and refpiration; and is increafed by reft, indolence, and four and vifcid aliments. Hitherto, we have been fpeaking of the adult liver, in which both the umbilical vein and the ductus venofus are empty, although they cohere with the left branch of the vena portarum.

DCXCIX. The nerves of the liver are rather numerous than large; hence, when wounded or inflamed,

flamed, it caufes a moderate degree of pain. They have a twofold origin. Moft of them arife from the large gangliform plexus of the fplenic branch of the intercoftal nerve, with the addition of a branch from the pofterior plexus of the eighth pair; they accompany the hepatic artery, and, playing around its trunk, go to the liver, with that and the branches of the vena portarum. Another fafciculus of nerves ufually enters with the ductus venofus, and arifes from the pofterior plexus of the eighth pair, but fometimes, from the great plexus.

DCC. The lymphatic veffels of the liver are numerous, and may be conftantly and eafily feen about the portæ. They arife from the whole concave furface of the liver, and from the furface of the gall bladder, run together into a plexus, furrounding the vena portarum, and go to the conglobate glands, feated before and behind the faid vein; from whence they meet together in one large trunk, which is one of the roots of the thoracic duct. Upon the convex part of the liver, are defcribed other lymphatics, whofe infertion is not well known; for it is hardly probable that they enter the cava, nor have they been fufficiently often traced to the receptacle of the chyle.

DCCI. The interior fabric of the liver is more obfcure. Through the whole liver, bundles of biliary veffels, of branches of the vena portarum, and of the hepatic artery, are diftributed. Each veffel has both its proper cellular texture furrounding it, and ligaments of the fame fubftance, by which it is tied to its fellow veffels; and, laftly, the whole bundle is furrounded by cellular texture. The branches of the vena cava lie on the outfide of the others, being lefs accurately received into the fame bundle. Laftly, the ultimate branches of the vena portarum, cava, and hepatic artery, and of the biliary ducts, which we fhall foon defcribe, are united

ted together by means of cellular ſubſtance (dcxcvi.) into a ſort of acini of a ſomewhat hexagonal ſhape, ſurrounded with lax cellular ſubſtance. In theſe bunches, likewiſe, there are mutual anaſtomoſes of the branches of the vena portarum, and of the hepatic artery, with the roots of the vena cava, and of the branches of the vena portarum, with the firſt origins of the pori biliarii; which laſt connection is demonſtrated by anatomical injections; for liquors injected into the vena portarum, at laſt return through the porus choledochus.

dccii. Many eminent anatomiſts have taught, that theſe acini are hollow, having arteries and veins ſpread upon their external ſurface, and that the bile, ſecreted from the branches of the vena portarum, is depoſited into their cavities. They derive their arguments from the anatomy of brutes, in whoſe liver the acini are round, and more defined than in man; and from diſeaſes, which exhibit cells and round tubercles, filled with lymph, chalk, and various kinds of concreted matter. To this, they might have added the lentor of the bile, by which it reſembles mucus, and the analogy of the follicles of the gall bladder.

dcciii. But greater accuracy in anatomy does not admit theſe follicles into which the ſmall ſecretory veſſels are ſaid to open; for ſuch would intercept the courſe of wax injections, and would occaſion intermediate knots betwixt theſe veſſels and the biliary pores, which have never yet been ſeen: for the wax flows in one continued thread, without any retardation, effuſion into a cavity, or diminution of its impetus, from the vena portarum into the biliary ducts. Nor could the great length of the biliary ducts admit of a glandular fabric. For all follicles depoſite, at no great diſtance, their fluid, which is not fitted for a long courſe, as they deſtroy ſo great a part of the velocity received from the arteries. Laſtly,

Laftly, the very common preffure, would fo crufh thefe bundles of acini, which we muft fuppofe, that the motion of the excretory duct could derive no affiftance from thence. The concretions and hydatids are formed in the cellular fubftance; and, laftly, the bile, when firft fecreted, is fufficiently fluid.

DCCIV. Again, we are convinced, that no bile is feparated from the hepatic artery, by the peculiar ftructure of the vena portarum, which would be ufelefs if it fecreted nothing; by the continuity of its branches with the biliary ducts, which is much more evident than in the arteries; by the experiment, in which it appears that the biliary fecretion continues after the hepatic artery is tied; by the great fize of the biliary ducts, in proportion to fo fmall an artery, and by the peculiar nature of the blood collected in the vena portarum, which is perfectly adapted for the fecretion of bile. For it contains both oil, which abounds more in the bile than in any other humour of the body; and a faponaceous fluid, abforbed from the ftomach, and the alkalefcent fubfetid vapour of the abdomen, brought back from the whole furface of the inteftines, ftomach, omentum, liver, fpleen, and mefentery, as we know by evident anatomical experiments; and, finally, the alkalefcent femiputrid, acrimonious humidity, abforbed from the alvine fæces themfelves, while they are indurated in the large inteftines, and brought thither by the internal hæmorrhoidal veins, from whence that bitternefs, alkalefcent and putrefcent difpofition of the bile is derived. But in the blood of the hepatic artery, there is nothing which renders it peculiarly fitted for the fecretion of bile, or analogous to it.

DCCV. Since, therefore, the vena portarum conveys the blood, in its fitteft ftate, for the fecretion of bile, to the ultimate acini of the liver, (DCCIV.) as there the paffage, from each branch of the

vena

vena portarum, into the beginning of the biliary ducts, is direct without any intermediate follicle, and as fluids injected into the vena portarum readily take this courfe, the bile will be propelled that way by the force of the blood furrounding it, and urging it from behind, and alfo by the acceffory force of the diaphragm preffing the liver againft the reft of the vifcera in the very full abdomen, (DCLXXXIX.) and again of the thorax, contracted in exfpiration, it will be forced into the larger branches, and laftly into the two trunks of the hepatic biliary duct; which trunks meet together in one on the vena portarum, and in the tranfverfe foffa of the liver, near the anonymous lobe.

DCCVI. This duct is compofed of a ftrong nervous membrane, like that of the inteftines, and of an external and internal cellular coat, and of a villous coat, loofe, elegantly reticulated, but afperated with many fmall pores and finufes, and continuous with that of the inteftine. There is no certainty of any mufcularity. From experiments, it appears to have a moderate degree of irritability. That it is vaftly dilatable, is fhown from difeafes. They feem alfo to fhow that this duct is poffeffed of great fenfibility.

DCCVII. The hepatic duct, thus formed, goes along the vena portarum, more to the right than the artety, towards the pancreas; and then defcending obliquely, covered by fome part of that gland, it comes in contact with the back and lower part of the fecond flexure of the duodenum, about fix inches from the pylorus; paffes through an interval in its flefhy fibres; meets with an oblique oblong finus, made by the pancreatic duct, and opens into it by a narrow orifice. This finus defcends obliquely a long way through the fecond cellular coat, of the duodenum, perforates the nervous coat, and again runs obliquely between it and the villous tunic; and, laftly, opens into a protuberant long tailed

ed wrinkle of the duodenum. Between the firſt arrival of this duct at the duodenum and its orifice, a ſinus, almoſt an inch long, which receives the ductus choledochus, is incloſed between the membranes of the inteſtines, ſo that when this inteſtine is filled, or diſtended by flatus, or cloſely contracted by a violent periſtaltic motion, it muſt be conſequently compreſſed and ſhut; but when the duodenum is relaxed, and moderately empty, it diſcharges itſelf. Any regurgitation from the duodenum is hindered by this obliquity, and by the wrinkle, which is eaſily preſſed together, or cloſed, and by the very eaſy deſcent of freſh bile through the duct. Even air does not find its way from the inteſtine into the duct.

DCCVIII. But in the very portæ, this duct receives the addition of another leſs canal of the ſame kind, for a good way parallel, and adhering to it, and inſerted into it in a very acute angle. This is called the cyſtic duct, from its origin, and is ſometimes firſt increaſed by another duct from the liver. It ariſes from the gall bladder, which is found in moſt animals; but is abſent in ſome, eſpecially the ſwift footed, and perhaps only the herbivorous. It is contained in an excavation of the right lobe of the liver, (DCCXCII.) to the right of the anonymous lobule, in ſuch a manner, that in young people, it lies entirely within the edge of the liver, but in adults projects conſiderably beyond it, lying upon the colon. Its ſituation is tranſverſe, from before backwards; its neck aſcends a little.

DCCIX. The figure of the gall bladder is variable, but in general like that of a pear; it is terminated before by an obtuſe, hemiſpherical, impervious end; and gradually diminiſhes backwards; the neck or tip of this truncated cone being reflected againſt itſelf once or twice, and tied together by proper cellular ſubſtance; and having made another flexure upwards, ends in the cyſtic duct; which from thence

thence goes towards the left ſide of the hepatic duct. But this duct, being alſo contracted by many cellular bands, is internally marked with many protuberant wrinkles, which, conjunctly in the dried gall bladder, repreſent a kind of ſpiral valve; but being ſoft and alternate in the living body, they retard, but do not entirely obſtruct, the courſe of the bile either way, as is proved by experiments, made with air and preſſure. Beſides, it is reticulated like the gall bladder itſelf.

dccx. The outermoſt coat of the gall bladder covers only its lower ſide, being the common covering of the liver itſelf, ſtretched over the gall bladder, and retaining it in its ſituation. The ſecond is a looſe cellular coat. The third coat has ſometimes ſplendent longitudinal fibres, in different directions, ſo as obliquely to interſect each other. At other times, it has none; ſo that we may doubt of its muſcular nature, eſpecially as the irritability of the gall bladder is ſlow and obſcure. The nervous, ſecond cellular, and villous coats, are found as in the inteſtines, except that the laſt, as in the biliary ducts, is reticulated and full of cells. In the gall bladder, eſpecially about its neck, but even as far as its middle, we obſerve muciferous pores, capable of receiving a briſtle; and arteries, as in other places, diſcharge ſome watery humour into the cavity of the gall bladder, and bile eaſily tranſudes through inorganic pores to the ſurface of the gall bladder, and neighbouring membranes.

dccxi. All animals, between their gall bladder and liver, or between their ducts, have alſo ſome peculiar openings into the gall bladder, into which ſome ducts, originating from the liver, or from the hepatic biliary duct, open. In man, ſimilar ducts have not been ſhown by any certain experiment, and the gall bladder, when full of bile, is eaſily ſeparated from the liver, without a drop of bile eſcaping either from it or from the liver. There is alſo a

thin

thin water in the bladder as often as the cyſtic duct is obſtructed.

DCCXI. The bile naturally flows both out of the bladder and liver, whenever there is no impediment in its courſe; ſo that both ducts ſwell when the paſſage is obſtructed, and the cyſtic lies in a ſtraight line with the choledochus. Nor is it probable that the whole of the bile is ſent into the gall bladder before it flows into the duodenum. There is not a perpetual obſtacle which hinders its efflux, and peculiarly obſtructs the hepatic bile, and admits the cyſtic; the paſſage into the ductus choledochus is larger and ſtraighter, the ductus cyſticus much leſs than the hepatic, and therefore not formed for receiving all the bile; the choledochus, much larger than the cyſtic, and therefore not appointed for the reception of its bile only. There are many animals in which the hepatic duct enters the inteſtine without any communication with the cyſtic. In living animals, even when the cyſtic duct is free, the bile appears to deſcend into the duodenum with a perpetual current. That the quantity is very conſiderable, appears from the magnitude of the ſecretory organ, and of the excretory duct, which is ſo many times larger than the ſalivary ones; from diſeaſes, in which four ounces of cyſtic bile only have flowed out daily through an ulcer of the ſide. But the hepatic bile goes into the gall bladder, as often as there is any obſtruction in the duodenal ſinus, from flatus, or any other cauſe compreſſing the orifice of the ductus choledochus. Accordingly, it is found extremely full, whenever the common biliary duct is compreſſed by any ſcirrhoſity or tumour, and it is ſometimes enlarged beyond all belief; if the cyſtic duct be tied, it ſwells betwixt the ligature and its union with the hepatic duct; and in living animals, the hepatic bile has been ſeen to diſtil into the wounded gall bladder. This is not inconſiſtent with the retrograde angle, for

for a very ſlight preſſure urges the bile from the liver into the gall bladder; and air eaſily takes the ſame way, more eſpecially if the duodenum be firſt inflated. Nor does there ſeem to be any other bile ſecreted by the gall bladder. Whenever the cyſtic duct is obſtructed by a calculus, or by a ligature made upon it, we find nothing in the gall bladder, except a ſmall quantity of inſipid mucus, ſecreted from the follicles, (DCCX.) or ſome watery exhalation. In many animals, we meet with no appearance of a gall bladder, when, nevertheleſs, plenty of acrid and ſalutary bile is diſcharged into the inteſtines. It does not ſeem probable, that any bile is ſecreted in the gall bladder from the cyſtic branch of the vena portarum, for that is a mere returning veſſel; nor from the hepatic artery, for it is ſcarcely probable, that the very acrid cyſtic bile ſhould be ſeparated from a milder blood than milder hepatic bile prepared from appropriated blood (DCCIV.)

DCCXII. Laſtly, the bile flows alſo from the gall bladder to the liver, and at length returns into the blood, when its paſſage into the inteſtines is totally intercepted, ſometimes alſo from a latent cauſe exiſting in the nerves. This courſe is morbid, and produces the jaundice; which, therefore, is cured by the paſſage of the calculi, and by reſtoring its free courſe.

DCCXIII. Therefore, a portion of the hepatic bile being received into the gall bladder, ſtagnates, being only gently agitated by reſpiration, and there exhales its thinner parts, which we ſee extenſively diffuſed over the adjacent membranes. The remainder, being oily and ſubalkaline, from its warm ſituation, grows acrid and rancid, and its thickneſs, bitterneſs, and colour are increaſed; nor is there any other difference betwixt the cyſtic and hepatic bile, which laſt we find in the ducts, leſs bitter, leſs dark coloured, and leſs viſcid. That this difference proceeds only from ſtagnation, appears from ſuch animals

animals as have only a larger porus hepaticus, inſtead of a gall bladder; for the bile which ſtagnates there, is remarkably more bitter than that in the liver; as, for example, in the elephant. But the gall bladder gives this particular advantage, that it receives the bile, when, the ſtomach being empty, it is of no uſe, and ſupplies it more quickly when we principally want it for the digeſtion of the aliments, now flowing in great quantity into the duodenum. This quickneſs is greater in proportion as the cyſtic duct is ſmaller than the gall bladder.

DCCXIV. The gall bladder, indeed, does not touch the ſtomach, but the beginning of the deſcending duodenum. But when the ſtomach is diſtended, and occupies a conſiderable ſpace in the very full abdomen, it both preſſes the liver and duodenum, and compreſſes the gall bladder, and empties it. Thus the bile flows through a free paſſage, from the gall bladder into the biliary duct, and into the duodenum; moſt eaſily in perſons lying on their back, for then the bottom of the gall bladder is uppermoſt. Hence the gall bladder becomes turgid after faſting. There is ſcarcely any other evacuating power than the ſtomach and diaphragm; for that reſiding in the proper muſcular and contractile membrane of the gall bladder, is very inconſiderable.

DCCXV. The hepatic bile is always bitter, but the cyſtic more ſo; always viſcid; of a full yellow colour, with a tincture of green; miſcible, by trituration, with water and oil, and with vinous ſpirits; coagulable by the mineral acids; ſoluble in the alkalies, eſpecially the volatile alkali; well adapted for diſſolving oily, reſinous, or gummy ſubſtances; of a lixivial and ſaponaceous nature; quickly putrefying, and by putrefaction ſpontaneouſly acquiring the odour of muſk. Its chemical analyſis, and experiments of mixture with various ſubſtances, demonſtrate, that it contains a large portion of water, and

and a confiderable quantity of the inflammable oil, which is fo evident in cyftic calculi. It therefore, is a foap; but of that fort which is compofed of a volatile alkaline falt, mixed with oil, and retains its water. Therefore, being intermixed with the aliment, reduced to a pulp and expreffed from the ftomach by the periftaltic motion of the duodenum, and preffure of the abdominal mufcles, it in a great meafure overcomes the acefcent qualities of the food; it diffolves the coagulum of milk, and difpofes the aliment more to putrefcency; it diffolves the oily matters, fo that, by freely incorporating with the watery parts, they may form chyle, and enter the lacteals; it abfterges and attenuates the mucus; and, laftly, excites the periftaltic motion by its acrimony; all which offices are confirmed, by obferving the oppofite difeafes to arife from a want of bile. Nor is the hepatic bile fufficient to evacuate the inteftines, if the cyftic is wanting. So great is its utility, that perfectly robuft animals have been found to die in a few days, by preventing the afflux of bile to the inteftines; or deftroying the gall bladder.

DCCXVI. The bile gradually defcends along with the food, and is evacuated along with the fæces, fomewhat changed, its bitternefs being deftroyed by putridity. Perhaps fome of the watery, leaft bitter, and thinneft parts, are again taken up by the vena portarum. Its regurgitation into the ftomach is impeded by the afcent of the duodenum, at the bottom of which it enters, by the valve of the pylorus, and by the accefs of new chyle which the ftomach adds to the former: in man, however, it frequently happens, and in birds always. The bile in the fœtus is bland and fweet; for in them no fetid fæces fupply acrid alkaline vapours, nor is there any oil abforbed. As the bile is vifcid in fluggifh and fat animals; and in man from the fame caufes, and from grief, it readily forms hard coagulums,

either calcareous or reſinous, and much more frequently than the urine, according to our experiments. Its uſe is manifeſt, as, by trituration with the aliments, it diſſolves oil, reſiſts acidity, and ſtimulates the inteſtines to contraction.

DCCXVII. In the fœtus, beſides ſecreting the bile, the uſe of the liver is evidently to tranſmit the blood returning from the placenta, and, as it ſeems, to moderate its impetus. Even in the adult, it has the ſame uſe, though leſs manifeſtly, in retarding the return of the blood coming back from the chylopoëtic viſcera.

CHAP. XXIV.

SMALL INTESTINES.

DCCXVIII. BY the ſmall inteſtines, anatomiſts underſtand one continued, and almoſt cylindrical tube, whoſe tranſverſe ſection is nearly oval, the obtuſe end being towards the unconnected ſide of the inteſtine. This tube being continued for a long way from the end of the ſtomach, the right orifice of which it embraces, (DCXXV.) terminates by expanding into a larger inteſtine. Anatomiſts have uſually reckoned three ſmall inteſtines, though nature has formed but one. However, the duodenum has a tolerable fixed limit, at the bottom of that part of the abdomen which is above the tranſverſe meſecolon (DCLIX.) But that ſmall inteſtine which lies below this meſocolon, has no certain mark of diſtinction, by which the jejunum, commonly ſo called, is ſeparated from the ileum : for although the former abounds more with valves and blood-veſſels, and is furniſhed with longer villi, and there fore appears ſomewhat redder ; and the ileum again rather contains glands, and has fewer vaſcular ramifications ; theſe differences inſenſibly occur, without

out any certain limits, being great in their extreme, and obfcure in their contiguous terminations.

DCCXIX. The duodenum is denominated from its length. It is lax and large, efpecially in its firft flexures, becaufe in part it has no external membrane, and in part is not completely furrounded by it. It is florid and tender, and has flefhy fibres of confiderable thicknefs. It begins by adhering round the annular orifice of the pylorus; then it proceeds undulating, but on the whole tranfverfe, to the right and backwards in the empty ftomach, to the gall bladder, to the neck of which it becomes contiguous (DCCXIV.) From thence it defcends obliquely to the right, and backwards as far as the lower plate of the mefocolon, and the entrance of the biliary duct, and in that courfe is received betwixt the upper and lower plates of the mefocolon. From thence it again returns, tranfverfely, but at the fame time afcending, behind the pancreas and large mefenteric veffels, to the left, along with the left renal vein; it goes out from the duplicature of the plates of the mefocolon; and making a turn, it defcends on the right of the faid veffels, through a peculiar foramen, in which the mefentery, left and tranfverfe mefocolon, adhere to it, to the lower part of the abdomen, which it enters, and becomes the jejunum. The largenefs of this inteftine, its afcent from the infertion of the biliary duct, its fucceeding flexure around the root of the mefentery, caufe fome delay, by which the bile and pancreatic juice are here efpecially mixed with the alimentary mafs.

DCCXX. In the reft of the fmall inteftine there is no certain point; but with uncertain and infinite convolutions, not to be defcribed, it fills the lower part of the abdomen and the pelvis, furrounded by the colon, and alfo lies between the bladder and uterus.

DCCXXI. The fabric of the fmall inteftine is almoft the fame with that of the ftomach and œfophagus.

phagus. Excepting part of the duodenum, it receives an external coat from the peritonæum, or meſentery, applied to the acute vertex of the inteſtine, double, and ſeparated there by ſome cellular ſubſtance, often by fat, but cloſely embracing the reſt of the inteſtine, ſo that its muſcular fibres adhere to the external membrane, which does not at all differ from that of the ſtomach. By this external membrane, and by the meſentery (DCLXI.) the inteſtines are ſupported as firmly as is neceſſary, and with very great mobility.

DCCXXII. But the muſcular coat is different, from the difference of figure. The moſt conſiderable ſtratum of fibres in the inteſtines is circular; they ſurround the tube on every ſide, and are uniform, parallel, formed of imperfect arches, cemented into circles, pale, and yet remarkably contractile. The longitudinal fibres are, in the ſmall inteſtines, few in number, and ſcattered round their whole extent, but eſpecially laid over the others on the obtuſe vertex of the inteſtine.

DCCXXIII. Within the muſcular coat, is ſeated the ſecond cellular, larger, as in the ſtomach, ſpread on all ſides round the nervous coat, and in man rarely fat. But the nervous coat, as in the ſtomach, ſerves as the foundation for the whole inteſtinal tube; it is compoſed of compacted fibres, which, by inflation, may be ſeparated and diſunited, ſo as to aſſume a cellular appearance. Next follows the third cellular coat, which is almoſt like the ſecond. The innermoſt, the villous, differs from that which we deſcribed in the ſtomach: for, firſt, it is every where folded into wrinkles, generally ſemicircular, but alſo into others joining the ſemicircular ones obliquely, and into others variouſly irregular, into which the nervous coat ſlightly enters, but the third cellular enters deeply, lying between the doubled villous coat, and filling up the duplicature. Theſe folds begin within one inch of the pylorus, and are moſt

moſt numerous in the firſt half of the inteſtines, dut gradually diminiſh in number. In each of theſe a ſmall artery and vein lie upon the convex ſurface of its ſecond cellular coat. The firſt plicæ in the duodenum are confuſed, and lie nearly in the direction of the inteſtine. They are changed into acute circles and valves by anatomical preparation. They are indeed ſoft, and eaſily inverted, and yield to the paſſage of the alimentary pulp either way, but by their number they retard it, and enlarge the ſurface of the villous membrane.

DCCXXIV. Laſtly, the membrane is here truly villous, which in other parts is ſo named from analogy. Namely, the whole internal ſurface of the inteſtine, both the valves, and the intervening hollows, ſend out every where innumerable pendulous flocculi, reſembling ſilk velvet, which are conical, but ſomewhat obtuſe, productions of the inner coat of the inteſtine, containing cellular ſubſtance between the duplicature, and veſſels and nerves wrapped up in that ſubſtance, and likewiſe a lacteal veſſel, ſuch as we ſhall afterwards deſcribe, ſo as very much to reſemble the papillæ of the tongue, except in being ſofter.

DCCXXV. The chief veſſel of each of the villi is an oval veſſel, opening by a ſlender duct in the ſurface of the villous coat, often filled with a milky fluid, and ſurrounded by neighbouring veſſels.

DCCXXVI. In the internal ſurface of this villous coat, open an infinite number of pores; ſome larger, others ſmaller. The former lead to conſpicuous ſimple mucous glands, ſeated in the third cellular ſtratum, ſimilar to thoſe ſeated in the mouth and pharynx, having a very vaſcular follicle, and an orifice opening into the inteſtine. In the duodenum there are ſeveral of them which are contiguous, but do not run together, and cannot always be demonſtrated; in the ileum they are very numerous, both ſolitary, a few joined together, and in conſiderable numbers

numbers collected into an elliptical figure. They are ſurrounded by villous membrane.

DCCXXVII. The ſmaller pores are found throughout the whole inteſtines, and ſurround the baſis of the villi; they are moſt conſpicuous in the large inteſtines, where they have been long known, but have been lately diſcovered in the ſmall inteſtines likewiſe. Theſe alſo ſeem to depoſite a liquor of the mucous kind.

DCCXXVIII. The veſſels of the ſmall inteſtines are very numerous. The common larger trunk belonging to that part of the inteſtine that lies below the meſocolon, is called the meſenteric artery, which is the largeſt of thoſe produced by the aorta, and ſituated above the renal arteries. Deſcending behind the pancreas, to the right of the beginning of the jejunum, and beſides the colic branches, being eſpecially produced in a long trunk towards the right, to the bottom of the meſentery and termination of the ileum, it ſends numerous branches from its left ſide, the firſt and laſt being ſhorter, the middle ones longer. Theſe, ſubdividing into ſmaller, join with thoſe adjacent into convex arches; which again ſend out other branches, united in like manner, forming almoſt five ſeries of arches, until the laſt ſend, from their convexities, ſtraight and very numerous branches to the inteſtine.

DCCXXIX. The diviſion of theſe branches on the inteſtine, is very uniform; ſo that from the meſentery, through the firſt cellular coat, there is ſent one anterior, and another poſterior, which, having given ſmall branches to the outermoſt and fleſhy coats, penetrate to the ſecond cellular one: there the anterior trunk, running out towards the obtuſe vertex of the inteſtinal ellipſis, is continued ſtraight into the correſponding poſterior branch; and, according to its ſize, gradually ſends off ſmaller arbuſcular branches, inoſculating with the contiguous and oppoſite branches, by innumerable twigs. From this

this reticulation, branches penetrate through the nervous tunic into the third cellular ſtratum, and laſtly into the cavities of the villi, which finally, with open orifices, exhale their contents into the inteſtine. This courſe is eaſily imitated, by injections of water, ſize, or mercury. From recent obſervations, it has been added, that the arterial extremities open into an hollow veſicle, and there depoſite their liquor, which exudes through the common orifice of the veſicle. Beſides, the reticular diſpoſition of the arteries, and their numerous anaſtomoſes, have the effect, that the inteſtines are as little ſubject to obſtructions as poſſible, and that any obſtructing matter may eaſily return, by means of ſo many inoſculations, into the larger arterial trunks.

dccxxx. The laſt trunk of the meſenteric artery inoſculates with the ileo-colic. The duodenum has various arteries. The firſt, the uppermoſt from the hepatic, on the right, goes round the convexity of the curvature of this inteſtine, in the pancreas, and ſupplies this inteſtine, and inoſculates with another on the left, and inferior, the pancreatico duodenalis which makes a ſimilar arch in the pancreas, in the hollow of the curvature of the duodenum, and is at laſt inſerted into the lower duodenal arteries, produced by the meſenteric in its paſſage before this inteſtine. I willingly paſs over the ſmall arteries, which go from the ſpermatics to the duodenum, and from thoſe of the renal capſule.

dccxxxi. The veins, exactly correſponding with the arteries, meet all together, into the meſenteric trunk of the vena portarum; except the right duodenal vein, which goes immediately into the trunk of the vena portarum itſelf; and thoſe ſmall veins which accompany the ſmall arteries, (dccxxx.) and are inſerted into the ſpermatics and lumbals. Nor have I hitherto been able to diſcover any other veins of the meſentery, ariſing from the cava. It is a property

perty common to all these veins to be without valves, and to communicate freely with the arteries. In the villous coat, which is for the most part composed of veins, as the venous trunks are fewer and larger, they absorb from the intestines a thin humour; as appears from the injection of watery liquors, which readily take that course; and, from analogy, in aged persons, in whom the mesenteric glands, and consequently the passage of the lacteals, are frequently obliterated, and from the analogy of birds, which have no lacteals, and from the celerity with which watery liquors pass to the blood and through the kidneys, compared with the smallness of the thoracic duct, and chiefly from those experiments which have confirmed by ocular demonstration the passage of water from the cavity of the intestine into the vena portarum.

DCCXXXII. The nerves, numerous and small, impart to the intestines a considerable degree of sensibility; they arise from the middle plexus of the splenic nerves, which embraces the mesenteric artery, and play round it in great numbers, wrapped up in a very dense cellular substance. The duodenum has likewise nerves from the posterior hepatic plexus of the eighth pair. From the acute sensibility of the intestines, it is probable, that the ultimate branches of the nerves penetrate into the third cellular coat.

DCCXXXIII. From the exhaling arteries, a thin aqueous liquor distils into the cavity of the intestines, resembling the gastric juice, not acrid, but saltish. The very great quantity of this liquor is computed from the great size of the excretory orifices, and of the secreting arteries, which are not larger in any part of the body; and from the laxity of parts perpetually kept warm and moist, and from the copious diarrhœas or watery discharges that often follow the use of purgative medicines.

But

But the mucus arifing from the fources, DCCXXVI. DCCXXVII. lubricates the internal furface of the villous membrane, and defends the fenfible nerves from acrid or fpirituous alimentary matters. Hence, it is more abundant at the beginning of the large inteftines, becaufe there the mafs of aliment begins to be feculent, acrid, and tenacious.

DCCXXXIV. This liquor is mixed with the pulpy mafs of the aliment, with the bile, and with the pancreatic juice, by the external motion of the mufcles furrounding the abdomen; but this force is quite fmall, and unfit for moving forwards the aliments. And in the firft place, the periftaltic motion is not any where ftronger, or more evident, than in the fmall inteftines. For any part of the inteftine, irritated by flatus, or any fharp or rough body, contracts itfelf, even after death, very violently in that part where the ftimulus is applied, frees itfelf from the offending or diftending body, and expels it into the contiguous part of the lax inteftine; which alfo contracting from the fame ftimulus, repels what it received, either way. This motion occurs in various parts of the inteftines, without any certain order, wherever flatus or alimentary matter act as ftimuli. So great, however, is the aptitude of the inteftines, for motion, that they emulate, and even exceed, the irritability of the heart, or at leaft are fcarcely exceeded by it. When not irritated, they remain at reft, as I have often obferved; and we may fuppofe this to be the caufe why fat retards the belly. The air is the principal ftimulus of the inteftines, next the aliment, and laftly the bile. This motion is performed by a wonderful fort of alternate creeping and revolution of the inteftines, which diffection eafily demonftrates in living animals, and unfortunate cafes of wounds in the abdomen, and ruptures, have fhown in the human fpecies. And fince, here, among fo many inflexions, gravity can have no effect, the in-

teftine

teſtine when irritated, evacuates itſelf equally upwards and downwards. From this, the antiperiſtaltic motion is underſtood, by which the pulp of the alimentary maſs is longer expoſed to the gentle trituration of the inteſtine, and to the action of the diluent liquor, and of the abſorbing veins. All the contents of the inteſtines are at laſt determined to the large inteſtines, becauſe every ſtimulus begins in the left orifice of the ſtomach; and the conſtant ſucceſſion of food excites a new contraction in the parts above, by irritating them, while no contraction of the colon propagates a ſtimulus backwards to the lower part of the ileum; hence the looſe colon receives what deſcends into it, and unloads itſelf into the large unactive cæcum more eaſily, than it can repel upwards the aliments it has received, and which are reſiſted by the preſſure of the inteſtine propelling freſh matter. Anatomiſts obſerve, that this motion acts more ſtrongly downwards than upwards, and that the ſuperior parts of the inteſtines are more irritable. But as often as any inſuperable obſtacle reſiſts the paſſage of the aliment, the ſeat of the principal contraction will be there, and the aliment will be repelled upwards, even from the valve of the colon, through the whole length of the inteſtines, into the ſtomach, and laſtly into the mouth itſelf.

DCCXXXV. This periſtaltic motion, in which the inteſtine is conſtricted, is performed by the circular fibres, which are capable of moſt exactly emptying the tube, ſo as to propel downwards the moſt minute bodies, ſuch as needles or powders. But the revolutions of the inteſtines, drawn upwards or downwards, and the bending of the ſtraight, and the ſtraightening of the crooked portions, which are ſo conſpicuous in animals, are performed by the long fibres, and which, moreover, when they contract themſelves towards the ſeat of the preſent, ſtimulating

ting food, we ſee dilate the ſucceeding portion of inteſtine, and fit it for receiving. The ſame contraction, forces the villous membrane into the cavity of the inteſtines, and renders the folds longer; and expreſſes the mucus, ſo that ſuch a quantity is applied to the alimentary maſs, as is required by the irritation and degree of the ſtimulus. They alſo produce frequent, and generally harmleſs, introſuſceptions, by drawing up the ſucceeding portion of inteſtine, againſt that which is contracted, in ſuch a manner, that the former is received within the latter, which is relaxed.

DCCXXXVI. The alimentary pulp, therefore, diluted with the pancreatic juice and that of the inteſtines, intimately mixed with the ſaponaceous bile, and covered with mucus, is accurately triturated, and more efficaciouſly than in the ſtomach, in proportion as the ſides of the ſmall inteſtines approach nearer together, and to the length of the ſeries of the periſtaltic motion acting, and to the quantity of animal juices affuſed. The viſcid pulp, intermixed with air, becomes frothy, without fermentation, and the air continues to have the ſame effects as in the ſtomach, but ſo that every acid tendency within the inteſtines is counteracted. But the oily or fat parts of the food, diſſolved by the bile, (DCCXV.) and mixed with the watery juices, acquire uſually a bright white colour, like an emulſion, firſt viſible in the duodenum, below the entrance of the biliary duct; and afterwards adhering cloſely to the villous coat, throughout the whole length of the ſmall inteſtines. But the gelatinous juices of fleſh meats, diluted by copious affuſion of water, and being of themſelves of a ſubviſcid nature, adhere to the villous coat, and are prepared for abſorption. The water and watery liquors are all very greedily abſorbed by the veins: and yet the fæces never grow thick in the ſmall inteſtines, as far as I have obſerved, becauſe the water abſorbed is

repaired

repaired by the arterial vapour and the mucus; nor do they become fetid in any confiderable degree, both on account of the great quantity of diluting juices, and becaufe their quick progreffion does not allow them time for putrefaction. In the beginning of the jejunum, the white mafs is coloured with bile; in the end of the ileum, it is entirely mucous. Thofe remains, which are more earthy, grofs, coarfe, and acrid, and were excluded by the abforbing orifices, either by their own weight, or by fome power acting as a fphincter, defcend into the large inteftines, being gradually, forced down, fo as to complete their whole courfe in the fpace of about twenty-four hours. But within three or four hours, or a little more, almoft all the chyle is extracted.

DCCXXXVII. The confiderable length of the fmall inteftine, which is five times longer than the body, or more, the great furface of the villous membrane increafed by folds, the incredible number of exhaling and abforbing veffels, the flow progrefs of the food through the large inteftines, and the great quantity of the inteftinal juice, poured to the alimentary mafs, have the effect of providing abundantly, in the fmall inteftines, every requifite for diluting the food with our juices; for their abforption into the lacteals and the mefenteric veins; for the abfterfion of vifcidities from the inteftine; for preventing adhefions and coagulations; for the fuppreffion of any acidity, not yet fubdued; and for the deftruction of the deleterious qualities in many juices, which, being directly mixed with the blood, inftantly kill, but are without injury received by the mouth. Hence the inteftines are long in animals that feed upon any hard food, but fhorter in carnivorous ones, and fhorteft in thofe that live upon juices alone; and, in man, an uncommon fhortnefs of the inteftines has been attended with hunger, and fetid and fluid fæces.

DCCXXXVIII.

dccxxxviii. The heat, by which the aliment is fomented, and which is well fitted for the ſolution of the gelatinous matter, and for exciting the beginning of putrefaction, is therefore the principal cauſe of the fetor, which is gradually produced in the aliment; and alſo of that thinneſs by which the uſeful part of the aliment is fitted for abſorption. But the air alſo, incloſed in the viſcid aliment, operates, as in the ſtomach, by breaking the coheſion of the aliments, if any yet remain entire. The inteſtinal water dilutes the maſſes of aliment; and if any hard part remains, ſoftens it by maceration. The bile being intimately mixed with oil, diſſolves it, and renders it miſcible with water.

CHAP. XXV.

LARGE INTESTINES.

dccxxxix. WHAT remains, after the chyle has been abſtracted, conſiſts of ſome portion of the bile, but mucous and degenerate; ſome part of the human mucilage; moſt of the earthy parts that were in the food; all thoſe parts, which by their acrimony were rejected by the abſorbing mouths, changed, however, by putrefaction, (dccxxxvi.) with all the ſolid fibres and membranes, which reſiſted the powers of maceration and the periſtaltic motion.

dccxl. All theſe remains paſs from the extremity of the ileum into the cæcum, in which they ſtagnate; namely, the extremity of the ſmall inteſtine applies itſelf obliquely to the right ſide of the colon, reſting upon the right ileum and iliac muſcle, ſo that, upon the whole, it aſcends, but more with its lower ſide, and leſs with its upper, which is almoſt tranſverſe. But the extremity of the

the nervous and villous coats, and tranſverſe fleſhy fibres of the ileum, are ſo extended betwixt the departing fleſhy fibres and nervous coat of the colon, that there hangs within the cavity of this large inteſtine, a moveable, ſoft, double projecting fold, compoſed of the villous and nervous coats of the large inteſtine, and of the villous and nervous coats of the ſmall inteſtine, and of the interpoſed fleſhy fibres of the ileum and colon, connected by much cellular ſubſtance. The upper fold is tranſverſe and ſhorter, the lower is larger, longer, and aſcending. They are conjoined by a ſmall production of the ſame kind, more eſpecially where they approach in the right ſide. Betwixt theſe two folds, the mouth of the ileum opens, like a tranſverſe ſlit. By inflation, this ſtructure is much altered, aſſuming the appearance of membranes and hard valves. After the cellular ſubſtance is entirely removed, and the interpoſed fleſhy fibres are cut, the ileum, comes out from the colon, and the valvular appearance diſappears; but if a large part of it only be removed, ſo that it ſtill remoins inſerted by ſome, it reſembles a ſphincter.

DCCXLI. Below the entrance of the ileum, at the diſtance of ſome inches, the great inteſtine deſcends and reſts with an impervious extremity, upon the ileum. From the lower part of this, towards the right ſide, a very acutely conical ſmall inteſtine extends, in adults ſlender, in the fœtus proportionally larger, variouſly incurvated upwards, ſometimes downwards, and full of ſmall mucous glands, which pour out a glutinous matter to the fæces; in the fœtus, the colon itſelf is continued with a conical termination into the appendix. But the weight of the ſuperincumbent ſcybalæ, depreſſing the ſpace on the right ſide of the appendix; the ſtrength of the cellular texture uniting the left part of the cæcum with the ileum; the ſtrength of the fleſhy fibres uniting both inteſtines; the very contractile

contractile force of the ligaments; the fitnefs of the anterior fac of the cæcum, for eafily receiving the fæces from the ileum; all contribute to remove the appendix from the middle, fo that it arifes from the left fide of the extremity of the colon: and to form the thick and pendulous bag of the colon lying fartheft to the right fide, and which is peculiar to adults. When, therefore, the remains of the alimentary mafs come from the ileum into the colon, they fall by their weight into this impervious bag, and ftagnate there, and become putrid, both from the warmth of the place and their own nature; and here, efpecially, the fetor of the excrements begins.

DCCXLII. The inteftine which is continuous with the cæcum, and indeed the fame, is named the colon. This thick and very large inteftine, which is much ftronger than the fmall inteftines, begins in the right ileum, (DCCXL.) afcends along the kidney, lies in the angle of the right hypochondrium under the liver, and is connected to both vifcera by the peritonæum. Then it paffes under the liver and ftomach, for the moft part tranfverfely, to the fpleen, under which it lies, (DCLXXVI.) and in a deep recefs under the left ribs, it is often reflected upon itfelf. Then it defcends again, and having made a large flexure to the left ileum, (DCLVIII.) it is continued with the lower part of this flexure into the pelvis, and becomes the rectum.

DCCXLIII. The ftructure is, on the whole, the fame with that of the fmall inteftines, but it differs in feveral particulars. And firft, all the longitudinal fibres are collected into three bundles, which run through the whole extent of the inteftine; and of thefe one, and that the largeft, lies naked; another, at its origin, is concealed by the omentum, and the third by the mefocolon. Thefe are fhorter than the inteftine, and contract it fo that the nervous and villous membranes (DCXLIV.) project inwardly.

wardly. Thefe fibres are connected moft accurately with the external coat of the inteftine; but in the intermediate places, and chiefly at the mefocolon, is feated the firft cellular coat replenifhed with fat. Being dilated at their origin, they adhere to the vermiform appendix. In the extremity of the colon, there are often only two ligaments, the two fmaller joining into one. They diffufe themfelves upon the rectum fo as to cover it entirely.

DCCXLIV. Again, the flefhy and nervous coat, third cellular and villous tunics of the colon, are extended into much larger wrinkles in the parts betwixt the ligaments, often projecting in a threefold rank, which being fuftained by the ligaments, are able to fupport a little the fcybalæ, and refift their relapfe. In the beginning of the colon, they are very exactly threefold; but in its progrefs, they vary more and more, being lefs, and double, and folitary, and fmall and large intermixed, and entirely abfent. Where the ligaments which contract the colon, difappear, thefe valves difappear almoft entirely. Laftly, the villous coat is thinner, and without villi, but wrinkled and porous, furnifhed both with large pores leading to proper, large, round, folitary follicles, and with innumerable fmall pores leading to fmaller follicles. Both kinds fupply a great quantity of mucus.

DCCXLV. The blood-veffels of the large inteftines are partly from the greater and left mefenterics, and partly from the hypogaftrics. The middle colic artery arifes from the large mefenteric trunk, as that defcends behind the tranfverfe mefocolon. It rifes upwards with one, two, and fometimes three branches to the tranfverfe mefocolon, and unites on the right fide with the ileo-colic; and on the left, with the lower mefenteric, in a very large arch, which is the largeft of all the arterial inofculations in the human body. Again, under the mefocolon, from the fame large mefenteric artery, a larger

larger branch goes directly to the valve of the ileum with the colon, and inosculates upwards at the right of the colon with the middle colic; and to the left with the mesenteric; but from the middle of the mesentery it gives a branch that runs along the mesocolon of the appendix vermiformis, and terminates with two branches in the two folds of the ileum and colon, both the anterior and posterior. Lastly, the lower mesenteric, arises by its proper trunk from the aorta, betwixt its bifurcation and the renal arteries, and goes to the left part of the colon: upwards it forms a large arch, with the middle colic; downwards in three or four trunks, it spreads over the iliac flexure of the colon, and descends even into the rectum. There the rectum receives various branches from the middle hemorrhoidal, arising from the last trunk of the hypogastrics, and conjoined with the former. The ultimate arteries are from the same trunk, but arise without the pelvis. I pass over the smaller colics, arising from the spermatics, intercostal, omental, capsulary, and lumbar arteries. The veins, like the arteries, run together into the gastrocolic, and the internal hemorrhoidal, and thence into the vena portarum; and into the middle and external hemorrhoidals, and the trunks of the iliacs.

DCCXLVI. The division of the vessels to the large intestines, differs much from that of the small intestines. Their arches are less frequent and less often subdivided; the trunks follow the course of the intestines a long way; the glands seated on them are fewer; the branches on the intestines less arbuscular, divided at less angles, and more tortuous; and the reticulation in the cellular substance is loofer. An exhaling moisture distils into the cavity of the intestines, and the veins likewise absorb a thin fetid vapour from the fæces. The external, and perhaps also the internal veins, swelling into varices, pour out the hemorrhoidal blood; which

is always unnatural, although ſometimes infractions of the veſſels of the porta are relieved by that evacuation.

DCCXLVII. But there are alſo lymphatic veſſels, ariſing from the whole tract of the colon, and from the rectum, which unite with thoſe of the loins. We are not without examples of chyle having been found inſtead of lymph, in theſe lymphatics, ariſing from the colon; a proof, that even in this place ſomething ſtill remains, which may be added to the blood with advantage.

DCCXLVIII. The nerves proceed from the left colic plexus compoſed by the deſcending branches of each renal plexus, and others ariſing from the intercoſtal trunk in the thorax and loins, and others from the large meſenteric plexus. Theſe accompany the lower meſenteric artery, and go to the colon. The lowermoſt nerves ariſe from the plexus juſt mentioned, and go to the rectum, within the pelvis; others go to the ſame inteſtine from the lower intercoſtals, and from the nerves of the ſacrum. Theſe nerves are not numerous, and the inteſtine is not very ſenſible, that it may endure the hard and acrid fæces.

DCCXLIX. The inteſtinal fæces, therefore, retained in the blind beginning of the large inteſtines, (DCCXL.) become dry by the abſorption of their fluid parts, ſhaped by the round and contracted colon, aſcend from the bottom of the cæcum, being elevated by the long ligaments, which unite in the worm like appendix. And here the manner in which the fæces are propelled by the contraction of the circular fibres, appears better than in the ſmall inteſtines. The longitudinal fibres being drawn towards the contracted portion of the inteſtine, as to a fixed point, draw the lower part of the inteſtine upwards, and dilate it; then the next part of the inteſtine, to which the fæces are brought, being irritated in like manner, contracts the long fibres

towards

towards it; by a fucceffive repetition of which action, the fæces finifh their courfe through the whole large inteftine; for the moft part within twenty-four hours in a healthy perfon. For this periftaltic motion of the large inteftines may be feen in living animals, and in the human body from wounds; it is alfo confirmed by the antiperiftaltic motion, and by the phenomenon of glyfters being difcharged through the mouth. The fame fibres refift the air contained in the inteftines; and flatulence is faid to be generated as often as they are overcome and yield, and the inteftine is dilated.

DCCL. While the grofs fæces afcend from the cæcum along the folds (DCCXL.) or valves, at the entrance of the ileum, they incline the lower fold to the left, and backwards, and draw down the ligament common to both valves, and thus deprefs the upper fold downwards: thus the paffage is accurately fhut, fo that nothing may return into the ileum; which, however, cannot be done fo accurately in a fluid ftate of the fæces. The fæces, when falling down from the upper parts, deprefs the upper valve, and thus accurately exclude themfelves. This happens very exactly with hardened fæces, but not fo accurately with fluid fæces. From thence, becoming more and more dry and figured, they continue to move flowly forwards by the fame caufes (DCCXLIX.) through the whole colon, which is repeatedly bent, and of five or feven feet in length, in fuch a fpace of time as is fufficient to give no interruption to the affairs of human life; and which is lefs than twenty-four hours, by the time the alimentary mafs remained in the fmall inteftines.

DCCLI. At length the hardened excrement falls into the rectum, which is at firft inclined downwards, and then alfo forwards, of a broad and flat figure, at firft contiguous to, and afterwards fpread under the bladder, or vagina, but connected more with the latter than with the former. Here the fæces

are collected for a great while, and often to a great quantity, being a part which is loose, or surrounded with soft viscera and muscles, and much fat.

DCCLII. The structure of the rectum differs very much from that of the other intestines. The external membrane or peritonæum covers it only before, while behind it is connected to the region of the os sacrum, by a very broad stratum of cellular substance, replenished with fat, and many conglobate glands. The muscular fibres are much stronger than in the other intestines, especially the longitudinal ones, which being composed of the three ligaments, expanded and separated, first occupy the anterior face, and then the whole intestine: they dilate it against the advancing fæces, and draw it back after they are excluded. But the transverse fibres are also strong, and their last oval, tumid ring, is the internal sphincter by which the opening of the anus is accurately closed.

DCCLIII. Moreover, the villous tunic, which is extremely full of pores, and rough with polygonous and tender wrinkles, has likewise some sinuses peculiar to itself. Namely, the part of the intestine next to the skin and inferior orifice, forms a white firm valvular circle, into which descend longitudinal folds, but incurvated and approaching to each other on the circle itself. Betwixt those folds, therefore, sinuses are interposed, hollow upwards, and of a greater depth towards the bottom. Into their cavities open mouths from large mucous glands; while the margin of the anus itself is defended by sebaceous glands, that it may not be excoriated by the hard and acrid fæces.

DCCLIV. There are also proper muscles which govern the anus. The external sphincter is broad and fleshy, and consists of two plates of semi-elliptic fibres, which cross each other towards the coccyx, and towards the genital parts. And, in the former place, they are inserted by fleshy bundles into a callous

callous cellular fabric defcending from the coccyx. In the latter, in like manner, they are attached by fimilar bundles to the fkin of the perinæum ; but by three ftronger than the others, one middle, and two lateral into the accelerator and bulb of the urethra, the lateral ones partaking both of the nature of a fphincter and levator. The fibres, therefore, of the fphincter, approaching to a ftraight line between their anterior and pofterior fixed extremities, clofe the opening of the anus, which lies between them. With the internal fphincter, the external one is conjoined by a flefhy portion, that they may operate together. Their action is voluntary and not perpetual ; for the anus feems to be clofed naturally, by the narrownefs of its orifice, compared with the largenefs of the inteftine, by the wrinkles correfponding to the other (DCCLIII.) by the ftrength of the tranfverfe fibres of the internal fphincter, and by the incumbent bladder.

DCCLV. But the office of the levators is different. They are large and complicated mufcles. They defcend betwixt the oppofite offa ifchia, are placed under the rectum and bladder, and fuftain both, and prevent the rectum from defcending and gaping difguftingly. Moreover, by their fibres fpreading extenfively in the manner of a fphincter, and being joined to that mufcle, they can dilate its fibres, and open the anus ; but, at the fame time, they elevate and fuftain the inteftine from prolapfing while the fæces are paffing. They arife, as is well known, from the fpine of the ifchium, os ileum, and fynchondrofis of the offa pubis, terminating the margin of the great foramen of the pubes, and from that part of the ifchium, which is above the tubercle. Finally, they meet together under the coccyx, into which they are inferted by numerous fibres.

DCCLVI. Therefore, whenever the fæces are collected within the rectum in any great quantity, and

and become troublefome by the irritation of their weight, or acrimony, even to the adjacent vifcera; they are forced by the power of the will through the ftraits of the collapfed inteftine (dccliv.) by the force of the incumbent diaphragm, exerting an effort; which being drawn downwards with great force, preffes downwards the vifcera of the abdomen, which are alfo refifted by the contraction of the abdominal mufcles, and forces the contents of the bladder or rectum through the inferior opening between the bones of the pelvis, where the refiftance is leaft. When the refiftance of the anus is thus overcome, the force of the diaphragm abates, and the fæces are difcharged from the body, by the periftaltic motion of the inteftine itfelf. After the fæces are expelled, the inteftine is drawn back by its longitudinal fibres; and the anus being contracted by both its fphincters, fhuts its orifice as before.

dcclvii. Thefe fæces in man, and carnivorous animals, are very fetid, almoft putrid, fubalkaline, foft, and contain much oil mixed with faline matter, which are the remains both of the aliments and of the bile and other humours of the human body. An acrid and fetid water returns from the fæces into the blood; hence, coftivenefs in fevers is hurtful, as by its addition it promotes putrefcency.

CHAP. XXV.*

CHYLIFEROUS VESSELS.

dcclviii. THE chyle is a white juice (dccxxxvi.) extracted from the aliments, which is poured into the blood. It feems to be compofed of water and oil, as appears from its tafte, being fweet with fome mixture of faltnefs, from its acefcent

cent nature, from the whitenefs of its colour, from its fpontaneous feparation and coagulability, and from its lightnefs, by which it fwims on the blood: in all which properties it very much refembles an emulfion. It is compofed of vegetable farina, with lymph and animal oil. It every where retains the properties of the volatile and oily aliments. It changes into milk with very little alteration. But then, the glutinous pellucid ferum which it contains, becomes more manifeft, being coagulable into a kind of a jelly, by expofure to a high temperature, or by evaporating its water.

DCCLIX. That the chyle is abforbed into the lacteal veffels from the villous coat of the inteftines, to which it adheres, has been long known, by experiments with coloured liquids, which defcribed the fame courfe; from the fimilitude of the white liquor, as feen in the lacteals, and out of them and from the venous nature of lacteal veffels. But late experiments have given us better information on many particulars. The chyle is abforbed by the patulent orifice in the extremity of each of the villi, by a force fimilar to that of capillary tubes; is received into the hollow villi, which are relaxed when the inteftine itfelf is relaxed; but the veficle, being compreffed by the fucceeding conftriction of the mufcular fibres of the inteftine, the chyle is preffed on into the duct, which begins to appear in the fecond cellular ftratum. But there is a double feries of thefe trunks, one anterior, the other pofterior, as we obferved of the blood-veffels, (DCCXXIX.) From thence the lacteal veffel, already united into a larger canal, paffes into the firft cellular ftratum, and, in general, follows the courfe of the arteries, and likewife accompanies their arches, being conjoined with others of the fame kind into a very obliquely angled network. This kind of veffels hitherto has been obferved only in quadrupeds. In the large inteftine they arife without the

veficle.

vesicle. Very many arise from the first part of the small intestines under the mesocolon; some from the duodenum, and a few from the large intestines themselves.

DCCLX. The lacteal vessels are valvular in the very first cellular texture of the intestine, being provided, like the lymphatics, with very frequent, double, lunated valves, (LVII.) which admit the chyle passing from the intestines but prevent its return. Through this whole course, the chyle is propelled by the peristaltic motion of the intestines; by the peristaltic action of the vessels themselves, which are certainly irritable, even after death propelling the chyle; and by the considerable pressure of the abdominal muscles, directed by the valves.

DCCLXI. But betwixt the plates of the mesentery, at the divisions of the vessels, are found an infinite number of glands, of the conglobate kind, but softer and spongy, consisting of cellular texture full of juices, covered with an external membrane, less hard than in other parts, and variegated with numberless small blood-vessels. Some lacteal vessels seem to pass by these glands: the greatest number enter them; and, being divided and subdivided through their cellular fabric, compose the greatest part of the gland. On the other hand, other lacteal vessels originate in every gland; and, being mutually joined, compose trunks, of which the ultimate and largest go out from the gland. In the same manner the chyle enters two, three, or four glands, in succession; nor does any lacteal vessel arrive at the thoracic duct without entering some of these glands, although it may occasionally pass by some without entering them. That this is the true course of the chyle, and that it passes from the intestines to the mesenteric glands, appears from tying them, by the vessels growing turgid betwixt the ligature and the intestine; from schirrosities in the glands, by which they are rendered conspicuous; and from the nature

ture of the valves preventing any return to the inteftines.

dcclxii. What happens to the chyle in thefe cellular fpaces is not fufficiently known; but it appears that fome thin liquor is fecreted from the arteries in thefe glands, by the affufion of which the chyle is diluted. For it is obferved, that after the chyle has paffed all the glands, it appears more watery; and thin liquors, injected through the arteries, exude into the cells of the glands, and mix with the chyle, fince the lacteal veffels may be filled through the arteries. Laftly, this milky fluid appears manifeftly in the glands of infants.

dcclxiii. From the laft glands, which are collected together in the centre of the mefentery, a few very large lacteal veffels go out, to the number of four, five, or more, which afcend with the mefenteric artery, and intermix with the lymphatic plexus, which arifing from the lower parts of the body, creeps over the renal vein, and afterwards with that which comes behind the aorta from the lumbar glands, and with the hepatic. A duct is thus produced, fubject to great varieties, but which moft frequently expands into a veficle of confiderable breadth at the fide of the aorta, lying between that and the right appendix of the diaphragm, two or more inches long; and moft commonly continued above the diaphragm into the thorax, conical both ways: it is called the receptacle of the chyle. In this the gelatinous lymph of the limbs, and of the abdomen, mixes with the chyle, and dilutes its white colour; fo that fometimes it appears filled with a pellucid or reddifh humour, but frequently alfo with a white milk. But there are fome inftances where there are two or three fmall and narrow ducts, inftead of this receptacle. This, however, is moft frequent, and being compreffed by the diaphragm and aorta, propels the chyle with greater velocity, in proportion as

as its caliber is larger than that of the duct into which it empties itſelf. This receptacle is rarely ſo ſhort, that it may be compared with an egg; but for the moſt part it is broadeſt in the middle, and decreaſes conically towards each end.

DCCLXIV. That the chyle comes from the inteſtines into this duct, is ſhewn from injections, by which quickſilver has ſometimes been puſhed from the firſt lacteal veſſels into the thoracic duct; from ligatures made on the duct itſelf, or the red veins which receive it, by which the firſt and ſecond lacteal veſſels ſwell; and from the manifeſt flux of the chyle into the thoracic duct when the ligatures are removed.

DCCLXV. The thoracic duct, as it is called from its courſe, is generally ſingle; or, if double for ſome part of its courſe, it ſoon unites into one, which aſcends in a waving courſe behind the pleura, betwixt the vena azygos and the aorta; and receives in its way the lymphatic veſſels of the ſtomach, œſophagus, and lungs, paſſing through the conglobate glands, of which there are many incumbent on it, and collected into large bunches. It is, on the whole, cylindrical; and often forms iſlands, by ſplitting and uniting again, more eſpecially in its upper part. It has few valves, and thoſe leſs conſpicuous. About the fifth vertebra of the back, it generally goes to the left, behind the œſophagus, and then aſcends along the left ſide of the thorax, behind the ſubclavian veſſels, till it arrives near the ſixth vertebra of the neck.

DCCLXVI. Then, being reflected and often divided, it deſcends with each branch dilated into a ſort of veſicle, and enters, either with diſtinct or united openings, into the junction of the ſubclavian and internal jugular vein, by an oblique courſe from the upper, poſterior, and right ſide, downwards, to the left, and forwards; or going on with one or other branch, it enters the ſubclavian, on the outſide of that

that junction. It is guarded by a true, moveable, and almoft circular valve; alfo by its defcent the blood is prevented from entering it. It is rarely otherwife difpofed; and very rarely fplit into two, with one branch entering each fubclavian; and yet more rarely does it fend a branch into the vena azygos. Near its infertion it receives a large lymphatic veffel, coming tranfverfely from the arm; and another defcending from the head, in one or more trunks.

DCCLXVII. It appears that the chyle flows through the thoracic duct into the blood; becaufe, on tying the red veins, both the thoracic duct and lacteal veffels which are inferted into it fwell.

DCCLXVIII. I have attributed the firft caufe of motion in the chyle, and of its abforption, to the attraction of the capillary veffels, alternated with the periftaltic contraction of the inteftines. The attraction fills the villi; the periftaltic force empties them, and moves the chyle farther forwards. The reft of its motion feems to depend on the force of the membrane of the lacteal veffel itfelf, which, even after death, expels the chyle, fo that the veffels become pellucid, which before were milky. The alternate compreffing force of the diaphragm alfo has fome effect; and the motion of the chyle through the thorax is fomewhat accelerated by the receptacle, which, being compreffed, propels the chyle fo much the more quickly, as it is larger than the thoracic duct.

DCCLXIX. The chyle, mixed with the blood, does not immediately change its nature; as is proved from the milk produced from it. But five hours or more after a meal, almoft to twelve, during all which time a woman can afford milk; having circulated near 80,000 times through the body, fomented with the heat of the body, and mixed with the animal juices, it is changed, fo that its fat feems to be partly depofited in the cellular fubftance, partly

partly figured into the red globules, (CXLVII.) the gelatinous part changes into the ſerum of the blood; and the watery parts go off, partly by urine and perſpiration, and in part dilute the blood. Nor is it uncommon for a pellucid liquor to be in place of the chyle in the lacteals in a dying animal, or for a white liquor to be in one part of the meſentery, and limpid liquor in another, in veſſels which perfectly agree in their fabric. There are not, therefore, two kinds of veſſels from the inteſtines; of which the one carries chyle only, and the other lymph.

DCCLXX. When digeſtion is not going on, the lacteal veſſels abſorb water from the inteſtines, and are tranſparent, and the thoracic duct conveys the lymph of the abdomen, and of moſt parts of the body, to the blood (LIII.)

CHAP. XXVI.

KIDNEYS, BLADDER, AND URINE.

DCCLXXI. THE chyle, when taken into the blood, contains a great deal of water; the proportion of which in the blood would be too great, and its ſeparation into the cellular ſubſtance too eaſy, if it were not excreted. A part of it exhales through the ſkin, (CCCCXXXVI.) and another part, as large, or often larger, is ſtrained through the kidneys, and ejected from the body.

DCCLXXII. The kidneys are two viſcera, placed behind the peritonæum, one on each ſide of the ſpine, incumbent upon the diaphragm, and upon the pſoas and quadratus muſcles of the loins, but ſo that the right kidney is commonly placed lower and more backwards. Before the right kidney are placed the liver upon its upper part, (DCXC.) and then the colon and inteſtines; before the left kidney are the ſpleen, ſtomach, pancreas, and alſo the colon. They

are

are tied by reduplications of the peritonæum to the colon, duodenum, liver, and fpleen. Their figure externally is convex, and femi-elliptical; laterally they are flat, and inwardly concave; they are unequally divided into an upper, longer and thicker extremity, and into a lower, flat, flender extremity. They are firmly invefted by a ftrong external denfe membrane, which does not come from the peritonæum. Betwixt that membrane and the peritonæum of the loins, there is always interpofed a great quantity of fat, by which the whole furface of the kidney is furrounded on all fides, and the nidus is completed, which, though prepared for it, the kidneys would not totally fill. From the kidney the peritonæum afcends to the liver, fpleen, colon, and diaphragm, and forms as it were ligaments for the kidney.

DCCLXXIII. The veffels of the kidneys are very large, both the arteries, which together exceed the mefenterica, and the veins. The arteries arife from the aorta under that of the mefentery, not always in the fame manner, yet fo that the left is commonly fhorter than the right, and each of them frequently in two, three, or four trunks. From thefe arife the lower capfular arteries, and the adipofe ones belonging to the fat cortex of the kidney (DCCLXXII.) and not unfrequently the fpermatics. The fat, rather than the kidneys, receives fmaller branches from the fpermatic and lumbar arteries. The arteries are thick, fo that the proportion of their coats to their caliber is great; that they are among the ftrongeft of the body; and that they exceed the ftrength of the aorta by one third.

DCCLXXIV. The veins are large, efpecially the left, and lefs inconftant than the arteries: the right, which is often without a branch, is fhort and concealed; the left always receives one of the fpermatics, and the capfular, and the laft branch on that fide of the vena fine pari. It is a very large vein, and

and accompanies the duodenum, being extended transversely a considerable way to the left, before the aorta. Both the arteries and veins of the kidneys arise from the great trunks in an angle, acute downwards, and both divide themselves into several branches before they enter the kidney. That the passage of the blood from the renal arteries into the veins is very quick, appears from the facility with which water, wax, or air pass that way. The uppermost veins of the fat of the kidneys come from the capsular vessels, the middle from the renal ones, and the lowermost from the spermatics.

DCCLXXV. There are lymphatic veins, of considerable size, found near the renal veins, where they form the beginning of the receptacle of the chyle (DCCLXIII.) and which are said to receive the branches that are divided under the external coat of the kidney, and are rendered manifest by putrefaction, or by the injection of a fluid into the renal arteries, or even into the ureter.

DCCLXXVI. The nerves of the kidneys are small, but numerous; arising from a considerable plexus, mixed on each side with ganglions, which is generated by branches of the great semilunar ganglion, joined with others coming from the intercostal trunk, from within the thorax itself. They enter the kidney, along with the artery, and send off the middle mesenteric, (DCCXLVIII.) and the spermatic nerves. As these nerves are small, they give but a small degree of sensibility to the kidney.

DCCLXXVII. Upon the top of each kidney is seated the renal capsule; which in the fœtus is large, even larger than the kidney itself, but does not afterwards increase in the adult: it is glandular, of the conglomerate kind, divided into lobes, of an oval shape in the fœtus, and triangular in the adult; that on the right side is connected to the liver; the left to the spleen and pancreas; and both to the diaphragm and kidney, by as many sides. From careful

ful obſervation, it ſeems to be hollow within, ſeparable like a ventricle, with the internal ſurfaces ſmooth, as if cut, full of a liquor of a yellowiſh red colour, and fluid, almoſt like blood. The arteries of theſe capſules are many, and of three kinds; the uppermoſt from the phrenics, the middle ones from the aorta, and the lower ones from the renals; the veins are one on each ſide, the right one going to the cava, and the left to the renal vein. The ſaid vein creeps almoſt naked through the very ſmooth ventricle, in the ſulcus dividing the capſule, and ſends branches through its internal ſurfaces. Its uſes are as yet unknown; although we are led to believe, that it is ſubſervient to the kidney, eſpecially in the fœtus, from their conſtant vicinity in ſo many animals. It has no excretory duct, nor does it diſcharge any juice, by viſible pores, into the vein.

DCCLXXVIII. The internal fabric of the kidney is ſimple, and known. The veſſels enter the interval between the upper and lower portions of the kidney, and penetrate into its ſubſtance, ſurrounded with a cellular ſheath, and divide into branches, which run between the branches of what is called the pelvis, along the columns interpoſed betwixt the papillæ. From thence, having formed arches both in the papillæ and between them, they ſurround the origin of the papillæ, nearer to the periphery, ſometimes joined, but by ſmall branches: from whence proceed innumerable little twigs, of which ſome return by the intervals between the papillæ into the columns, and into the papillæ; and others tend towards the external ſurface of the kidney, and ſometimes paſs through the coat of the kidney, enter into its adipoſe covering, and are there changed into minute ſerpentine twigs, which being reflected towards the ſame portion of the kidney from whence their trunk aroſe, they are gradually extended, and intermixed with the uriniferous

ous tubes. But from the cortex, bundles of uriniferous tubuli arife in feveral rays, collected in great numbers into threads, of which each contains many tubuli. That they are continuous with the arteries, or at leaft that they receive their branches into them, we know, from experiments which fhew that water, or even air, paffes eafily from the arteries of the kidneys into the ureter; and, laftly, from difeafes, in which the blood itfelf takes the fame courfe. Between thefe papillæ, and about their origin, are fituated fome roundifh knots, which the lateft anatomifts confider as arterial glands, producing the proper and more narrow urinary ducts. Between thefe ducts many arteries run parallel. It is probable, that the cortex confifts of curved veffels, which eminent anatomifts have fuppofed to be fmaller than the red ones.

DCCLXXIX. Thofe uriniferous veffels gradually converge, being joined together like rays, and inferted in great numbers into one blind duct, which ducts complete the reft of the papilla, and terminate fingly in its convex extremity by confpicuous pores. The number of thefe papillæ is not altogether certain; but thirteen or more of them, fimple, triple, and even quadruple, have been feen. Thefe were in the fœtus fo diftinct, that the kidney then appeared to confift of as many diftinct fmaller kidneys, connected together by loofe cellular membrane, each of which was furnifhed with its proper cortex of ferpentine veffels, and its compages of ftraight uriniferous ducts; the bafis of all of them lay in the circumference of the kidney, and their vertices converged towards the centre. The oppofite cortices of two of thefe little kidneys make a column, which feparates the two papillæ. In the adult, the cellular fubftance being condenfed, draws the papillæ clofer, and unites them into one kidney; however, it again almoft recovers the condition which it had in the fœtus, if the cellular plates

be

are relaxed by injecting water into the veſſels. The kidney is alſo larger in the fœtus than in the adult.

DCCLXXX. Around the protuberant ſurface of each papilla, a looſe membranous diſtinct covering, of larger ſize, adheres; ſo that the papilla, or ſometimes two contiguous ones, project into the hollow tube of this cylindrical funnel. Two or three of the tubes unite together, and form by that union three hollow trunks, an upper, middle, and lower, which again unite, but on the outſide of the kidney, into one conical canal, called the pelvis.

DCCLXXXI. The blood of the renal artery being leſs moveable, as is generally believed, than that of the brain, and probably containing more water, and being brought by the ſerpentine arteries of the kidneys, depoſites into the rectilineal tubes of the papillæ a great portion of its water, and the oil incorporated with it, and the ſalts, and any thin fluid it may contain. But the ſmall diameter of each uriniferous duct at its origin, and its firm reſiſtance ſeem to exclude the groſs oil, and the chyle, and the coagulable lymph. Hence, the increaſed celerity of the blood ſo eaſily forces the red globules through theſe tubes, and, by morbid relaxation, they tranſmit the true fat and the chyle, and the ſalts of the meat and drink. But when the ſtrength of the kidney is reſtored by aſtringent medicines, the urine returns to its natural ſtate. The nerves likewiſe have a power of contracting or relaxing theſe paſſages; and thus the urine, which was of a yellow colour, ſuddenly becomes watery from violent affections of the mind. A vaſt quantity is prepared; equal to that of perſpiration, or ſomewhat greater.

DCCLXXXII. The urine, by heat or putrefaction, ſometimes by diſeaſe, and in ſome animals more eaſily, changes into a volatile alkaline ſubſtance, intimately mixed with oil; partly empyreumatic, yellow, and volatile; and partly very fixed, ſeparable only by the laſt degrees of fire, called phoſphorus,

 a congealing

a congealing ſubſtance, ſpontaneouſly emitting light, and taking fire in the air: and with earth in greater quantity than any other human fluid, both cretaceous and ſparry; the latter coming chiefly from the drink, the former alſo from the ſolid parts of the body themſelves, diſſolved and mixed with the blood. But there is alſo ſea-ſalt in freſh urine, and even after long putrefaction it is found in the phoſphorus, although a great part of it is changed into volatile alkali. Nor is the urine wholly deſtitute of an acid, ſimilar to the vitriolic, both in man and in animals. There is alſo a ſalt obtained from urine, which is fuſible by heat, cooling and analogous to nitre. In fevers, the oily and ſaline parts of the urine are augmented in quantity and acrimony.

DCCLXXXIII. The ureter, continuous with the pelvis, carries on the urine received from the kidney, by the preſſure of the incumbent viſcera, and of the abdominal and lumbar muſcles, and by the blood circulating and giving impulſe from behind; and, laſtly, by the weight of the urine. The ureter, covered by the peritonæum, is compoſed of cellular membrane; then of a weak and obſcure muſcular coat, if any: then a ſecond cellular coat; a firm, white, nervous one; a third cellular coat, and an innermoſt very ſmooth membrane, porous and glandular internally; and it is in general moderately irritable. It is of different diameters in different places, and every where ſwells into veſicles. It deſcends along the pſoas muſcle, acroſs the great iliac veſſels, arrives into the pelvis behind the urinary bladder; and, at the union of the deſcending and tranſverſe portions of the bladder, enters obliquely betwixt the muſcular fibres and nervous coat; and deſcends betwixt the nervous and villous coats, for a conſiderable way inwardly, ſo that the mouths of the two ureters are near each other, and open by a truncated orifice. They have no valves, either at their

their orifice, or in any part of their courſe. From their inſertion, a protuberant line of the thickened nervous coat deſcends towards the caput gallinaginis.

DCCLXXXIV. That the urine is ſeparated in the kidneys, is a matter of fact, as it can be emulged from its canals by preſſure. That it deſcends by the ureter, is ſhewn by the ſurpriſing ſwelling of the kidney, and of that part of the ureter which is above a ligature, and by the emptineſs of that part which is below it. That it paſſes into the bladder, is alſo proved, by the immenſe ſwelling of the ureters and kidneys, as often as the bladder cannot receive the urine, or cannot emit it; in conſequence of an obſtacle in either place.

DCCLXXXV. Nor does the urine ſeem to come in any other way. For although it be certain, that the ſtomach, like all other membranes, exhales; although it be not improbable, from experiments, that the bladder alſo abſorbs; and although the paſſage of acidulous waters be extremely quick; it does not follow, that there is a way, different from the ureters, to convey the water from the food to the bladder. For the bladder is, on all ſides, ſeparated from the cavity of the abdomen by the peritonæum; nor is it aſcertained that vapours, either exuding from the bladder, or tending towards it, can here find open pores in the peritonæum; and membranes which are already wetted and ſaturated with moiſture, do not imbibe much. But the urine alſo which is contained in the bladder, diſtends it even ſo as to occaſion death; and does not find any paſſage through which it can eſcape into the pelvis; and on the other hand, when the ureters are obſtructed with ſtones, ſo that the bladder receives nothing from them, it is either quite empty, or contains a very acrid and thick urine, manifeſtly indicating that the water can find no way from the pelvis into the bladder. And a careful attention to the manner in

which mineral waters are difcharged by urine, demonftrates, that there is no fuch rapidity therein as is commonly imagined; but that the cold of the water drunk, like external cold applied to the fkin, ftimulates the bladder, fo as to make it difcharge immediately the urine it contains already fecreted, and not that derived from the drink juft taken. Again, the largenefs of the renal veffels demonftrates, that not much lefs than an eighth part of the blood of the whole body is fent to the kidneys; and, confequently, above 1000 ounces of blood in an hour; fo that it is not furprifing that 20, or even 50 ounces of water, are feparated from the blood in that fpace of time. Finally, it is certain, that both man and animals perifh if the ureters be tied or obftructed; nor, in thefe circumftances, is any urine found in the bladder.

DCCLXXXVI. The urinary bladder is feated in the cavity of the pelvis, which is an appendix to the abdomen, furrounded almoft on all fides by bones; but laterally, and at the bottom, only inclofed by mufcles; and in every dimenfion, larger in women than in men. It is fo fituated in it, as to cohere with the offa pubis by much cellular fubftance; then it receives from them the peritonæum, which is applied to a fmall part of it before; but behind the bladder, it defcends for a great way, almoft as far as the infertions of the ureters; from whence it proceeds to the rectum, or to the uterus in women. Behind the bladder, the feminal veficles, proftate gland, rectum, and levatores ani, lie under it. In the fœtus, the bladder being very long, and conical, extends above the offa pubis; but in adults, it hardly arifes above thofe bones, even when inflated, becaufe, in them, the pelvis is much larger and deeper in proportion to the body.

DCCLXXXVII. The figure of the bladder is, in general, oval, but its anterior furface is flatter, its pofterior more convex, and its inferior obtufe vertex, which

which refts upon the rectum, is very flat and broad. Such is the figure of it in the male adult: in the fœtus it is almoft cylindrical; and, in women, who have had many children, it is fo much flattened laterally, that it refembles a roundifh tetrahedral figure, of which the fections are triangular. This change feems to arife from the weight of the urine, which depreffes the lower parts of the bladder, and extends it in breadth, fo as to render it fhorter and broader. It is of different magnitudes; fo that, in fome difeafes, from irritation, and habitual contraction, it becomes very fmall.

DCCLXXXVIII. The fabric of the bladder is much like that of all large membranous receptacles. The firft membrane is cellular; in its forepart lax, and replenifhed with fat; behind, it is lefs fo, where it alfo unites with the rectum. In this, there is a network of veffels, chiefly of veins. Next to this follows the mufcular coat, which is very difficult to defcribe, confifting of pale contractile fibres, difpofed in various reticulated bundles, not continuous, but with intervening fpaces, in which the nervous coat lies uncovered. The principal ftratum of thefe is longitudinal; which, arifing before from the proftate gland, and frequently, though not always, fo connected to the fynchondrofis of the offa pubis, or the membranes covering it, as feemingly to arife from thence, afcend towards the conical fuperior extremity of the bladder; defcend over it, along the pofterior furface, become at that place very broad, and again terminate at the proftate; but at the fides they diverge, varioufly palmated, and are blended from the anterior and pofterior planes. Thefe fibres muft deprefs the bladder, and confequently propel the urine towards its lower part.

DCCLXXXIX. The remaining fibres are very difficultly reduced to any order. They fill the intervals of the former; arifing from the proftate, then inflected, they afcend, and form a ftratum, partly

oblique,

oblique, and partly transſverſe, the interior ones more ſo than the others, both in the forepart and back part of the bladder.

DCCXC. The contractile force of the bladder is gentle, but perpetual; ſo that it contracts from its greateſt dilatation to its ſmalleſt diameter, without any alternate relaxation, and remains long in its ſtate of greateſt contraction. The urine is its leaſt uneaſy ſtimulus; water injected is more ſo; and calculus, and every kind of irritation, the moſt inſufferable. When immoderately diſtended, it loſes its powers; ſo that either it cannot expel, or it cannot retain the urine.

DCCXCI. Within the muſcular coat is ſpread the ſecond cellular ſtratum, of an elegant fabric, inflatable, more tender, and ſofter than in the inteſtines. Next follows the nervous coat, continuous with the ſkin, and acutely ſenſible; the innermoſt, reſembling that of the ſtomach, is laſt; more obſcure; difficultly ſeparable from the nervous one; continuous with the epidermis; and, like it, eaſily reparable, extremely mucous, and folded into various wrinkles, without any certain order. In it, the pores of the cryptæ ſometimes appear, but not always eaſily, pouring out a viſcid and bland gluten. The mucus itſelf is very manifeſt, and is prepared in greater quantity in proportion to the irritation of the bladder. It is of the greateſt importance for diminiſhing the irritation of the acrid urine.

DCCXCII. The veſſels and nerves of the bladder coincide with thoſe which go to the genital parts, where we ſhall deſcribe them. Thoſe which come from the epigaſtrics are ſmall. Their principal reticulation is in the firſt cellular ſtratum, and there is another in the ſecond. Through the villous coat the exhaling arteries exhale, as we learn by experiment, from anatomical injections; and the abſorbing veins open, to which are owing the greater conſiſtence and higher colour of the urine, when retained.

retained. The lymphatic veſſels in the outer cellular ſtratum, are eaſily demonſtrated; but their origin is probably foreign from the adjacent inteſtine.

DCCXCIII. The urinary bladder is of the ſame nature with other membranous ſacs, ſo that it both tranſmits water from its cavity through the inorganic pores of its membranes, and abſorbs water when immerſed in it.

DCCXCIV. Into this bladder, the urine flows, in one uniform ſtream, as has been proved, in morbid and uncommon caſes, in which the extremities of the ureters were viſible to the eye, and there remains, and becomes more acrid and higher coloured, from the abſorption of its water. We are not fully acquainted with the cauſe, which retains the urine in the bladder. The ſphincter is obſcure; the depreſſion of the bladder ſeems to aſſiſt, which being convex, deſcends upon the rectum, behind the ſphincter, below its orifice, ſo that the urine does not reach the orifice of the urethra till collected in ſome quantity. It is certain, that the urine does not eſcape ſpontaneouſly even from the dead body.

DCCXCV. At length, the urine, by its bulk and acrimony, irritating the ſenſible fabric of the bladder, is expelled, firſt by the motion of the diaphragm and abdominal muſcles, by the preſſure of which, impelling the inteſtines againſt the bladder in the erect poſture, the urine makes itſelf a way through the narrow and impeded paſſage; and ſecondly, by the periſtaltic motion of the bladder itſelf, ariſing from the contraction of its muſcular fabric (DCCLXXXVIII. et ſeq.)

DCCXCVI. By the urine, beſides the water, and part of our food, much matter, that is noxious to the human body, ſeems to paſs off; eſpecially calcareous earth reſorbed from the bones and ſolid parts, and which would produce bony cruſts and calculi wherever it was retained; the ſparry earth of waters; an acrid oil mixed with ſalt, ſo as to aſ-

ſume

ſume a volatile nature. The urine, by its retention, diſpoſes to the generation of calculi, and to gout: when ſuppreſſed, it produces acute fevers; and laſtly, flows back to the brain, and is depoſited on it, and deſtroys it.

DCCXCVII. From the obtuſe vertex of the bladder, not exactly from its bottom, but further forwards, a canal with a ſmall orifice, continuous with the bladder, ariſes. It is denominated the urethra, and is compoſed of an internal membrane, which is evidently continuous with the epidermis, of ſurrounding cellular ſubſtance, and of a firm nervous coat. It is variable in its diameter and direction; in women, it is ſtraight, tranſverſe, and ſhort. I do not find a valve in its orifice.

DCCXCVIII. The urethra is at firſt ſurrounded on all ſides, by the proſtate gland; it then proceeds naked, for a ſmall ſpace; it is then embraced by the bulb immediately attached to it, firſt below, and then above; it is then received in the interval between the corpora cavernoſa of the penis, contiguous to it above, and laterally, and acquires ſtrength and the ſtate of an open tube from them. The urethra is wideſt where it ariſes from the bladder; it contracts itſelf conically in the proſtate; in its naked part it is cylindrical; it enlarges at the firſt acceſſion of the bulb; in the penis it is alſo cylindrical, and again dilates itſelf a little before its termination.

DCCXCIX. This canal is governed by various muſcles, either proper or contiguous. And firſt, in women, there are manifeſtly fibres placed round the egreſs of the incipient urethra, which are, on the whole, tranſverſe, but variouſly decuſſating each other; of which the fixed point is in the vagina, and the office is evidently that of a ſphincter, to depreſs the canal, about the opening of which they are diſpoſed, and to cloſe it againſt the reſiſting contracted vagina, and ſphincter of the anus. In

man,

man, ſimilar tranſverſe fibres, but forming an arch upwards, run into the conjunction of the bladder with the proſtate; both covering a longitudinal bundle of fibres and the proſtate, and covered by theſe fibres, they are to a certain degree fitted for contracting the orifice of the bladder.

dccc. The firſt tranſverſe muſcle proceeding tranſverſely from that branch of the iſchium which ſends forth the erector muſcle of the penis, towards the other os iſchium, partly paſſes into it, partly is inſerted into the middle of the bulb of the urethra, and partly degenerates into the accelerator. It preſſes upon, ſhakes, and draws backwards the bulb of the urethra. The other, produced from the branch of the os iſchium, is inſerted into the iſthmus of the urethra before the bulb, and dilates it.

dccci. But likewiſe the levator of the anus ſeems to raiſe the urethra againſt the os pubis, and to ſhut the exit from the bladder; and the conſtriction of the accelerator, together with the ſphincter, is eaſily perceived in the living body, as it perfectly cloſes the mouth of the bladder, and checks the urine even while it is flowing; whence there is no doubt, that the moderate tenſion of this muſcle contributes towards retaining the urine.

dcccii. An effort being now made, (dccxcv.) by the preſſure of the diaphragm, the urine is ejected with greater celerity, as it comes from a large receptacle, through a narrow canal; and, being diſcharged, the body is freed from the uneaſy ſenſation. The laſt drops, which remain in the loweſt part of the bulb, and are retained there by their weight, are expelled by the accelerator muſcle, which is a ſtrong muſcular expanſion, placed round the bulb of the urethra, with pennated fibres, meeting in the bottom middle part of the bulb, faſtened before by two tendons to the cavernous bodies of the penis behind, and connected by three muſcular portions to the ſphincter of the anus, of which two are lateral,

and

and one central, with ſome acceſſion from the tranſverſe muſcles. This muſcle, when the ſphincter is ſteady and ſhut, draws the bulb upwards; and, acting upon the urethra alternately, with conſiderable force, expels the laſt drops of the urine.

DCCCIII. We cannot admit, that the pyramidal muſcle of the abdomen, draws the bladder downwards from the bundle of umbilical veſſels, and relaxes it, and fits it for the action of the long muſcular fibres, as the muſcle itſelf is often wanting; as it cannot depreſs the bladder, and very rarely reaches the navel.

DCCCIV. But as the urine is acrid, and the membrane of the urethra very ſenſible, and as the air can be admitted into it, nature has ſupplied this canal with a large quantity of mucus. Beſides its ſources in the bladder, this mucus is generated, in the firſt place, by two conglomerate glands; one of which is ſeated on each ſide, in the angle betwixt the bulb of the urethra and the cavernous body of the penis, and ſends out a duct, running for a conſiderable way obliquely along the urethra, and inſerted before its bulb. I am ignorant of any gland of the iſthmus different from the cellular texture. Moreover, the whole urethra is full of cylindrical mucous ſinuſes, moſt of which deſcend towards the glans, though ſome run in a contrary direction, into whoſe ſides minute cryptæ depoſite a fluid and bland mucus. The largeſt of theſe ſinuſes are diſpoſed in a ſeries along the upper ſide of the urethra, beginning before the bulb, and extending to the origin of the glans. The ſmall ones are both mixed with theſe large ones, and diſpoſed on the ſides. In women, they are numerous and large in their ſhort urethra, eſpecially at its opening.

DCCCV. The neceſſary propriety of human life requires the detention of the urine. But this very utility is attended with the danger of diſeaſe, ſince the

the urine when at reſt, immediately depoſites its earthy particles, which by the acceſſion of new ſtrata, form calculi. But the great number of people free from calculi, ſhow, that the very lubricous mucus of the bladder is a ſufficient protection, unleſs the uſe of ſabulous and tophaceous water, of wine, or of viſcid aliments, exceſſive inactivity, preternatural retention of the urine, the preſence of ſome viſcid body to attract the calculous earth, and, finally, nephritic diſeaſes, afford a ſuperabundance of calculous earth, or a nucleus for its adheſion.

CHAP. XXVII.

MALE ORGANS OF GENERATION.

DCCCVI. THE veſſels belonging to the genitals ariſe near the kidneys, almoſt in every kind of animals. This is occaſioned by the opportunity of deriving a double uſe from one organ, which might diſcharge both the urine and the ſemen, and by the relation of the genital parts to the interval between the tops of the thighs, which is ſubſervient to cleanlineſs, modeſty, the facility of parturition, of making water, and to the effect of the efforts employed in theſe.

DCCCVII. The male ſemen is formed in the teſticle; is depoſited in the ſeminal veſicles; is ejected from the penis; is injected into the uterus, and fecundates the ovum. Such is the arrangement we ſhall follow. The human teſticles, ſmall in proportion to the body, in the fœtus, when very young, are lodged within the peritonæum, and gradually deſcend under it into the groins, and when it has arrived at maturity, they lie below the groins; their ſituation being changed, perhaps by the ſimple force of their weight, and of the influx of blood; yet ſometimes they remain in the groin, even in adults.

adults. They defcend by a cellular paffage, which in the fœtus is open, and called the procefs leading from the cavity of the peritonæum into the fcrotum; and the fame paffage, after the tefticle is tranfmitted, is contracted and obliterated by a law of nature.

DCCCVIII. The tefticles are defended by various integuments. In the firft place, they are furrounded by the fcrotum, which is formed of a denfe cellular coat, vafcular and compacted into a folid membrane, clofely adhering to the fkin, which poffeffes fome elaftic motion from cold and during venery, but without any mufcular fabric, although when it acts it becomes corrugated, and draws up the tefticles. This cellular coat, commonly called the dartos, is placed round each of the tefticles feparately; therefore, at their union, they form a kind of feptum, in a dry preparation; this feptum is often imperfect in its upper part, near the penis.

DCCCIX. The dartos is interiorly relaxed into cellular fubftance, which is inflatable as in other places, but without fat, except in the lower part of the fcrotum. Next follows a mufcle, from its office called cremafter; which arifes from the degenerating fibres of the lefs oblique mufcle of the abdomen, and from the tendon of the obliquus externus, which has got the name of a ligament, and fometimes from other fibres defcending from the os pubis, and being expanded into a vagina, and furrounding the tefticle behind, and then on all fides, it compreffes, elevates, and emulges it.

DCCCX. Next to this follows the fecond cellular ftratum, which is continuous with the exterior fpongy web, which furrounds the peritonæum; this is called the tunica vaginalis. It is compofed of longer cells than elfewhere, which may be inflated one after another. At the beginning of the tefticle, above the epididymis, part of the vaginal coat, which furrounds the tefticle, is fo feparated

rated from the reſt, which lies higher than the teſticle towards the ring of the abdominal muſcles, as almoſt to prevent the tranſmiſſion of air. Betwixt this membrane and the following, there is a ſpace, into which vapour is exhaled, and ſometimes a little water is collected. The innermoſt coat of the teſticle, called the albuginea, is a ſtrong, white, compact membrane, which immediately inveſts the ſubſtance of the teſticle.

DCCCXI. The teſticle properly ſo called, is of an oval figure, with an acute vertex, directed upwards and a little outwards. The epididymis is a kind of addition to the teſticle; a flat thick tape, which goes round the poſterior margin of the teſticle, to which it is connected by cellular texture, and by veſſels. Below it is flatter; on the upper part it adheres to the teſticle by a thick and convex head, as it alſo does at the very bottom. In the middle, it is partly attached, and being partly looſe, forms a ſhut cavity.

DCCCXII. To the teſticle the ſpermatic arteries deſcend, one on each ſide, ariſing from the aorta below the renal arteries; but not unfrequently from the renals themſelves, or from one of the capſulary, or from the aorta itſelf above the renal. This artery, the ſmalleſt in the body in proportion to its length, deſcends outwards before the pſoas muſcle, and gives ſmall branches to the liver, the fat of the kidney, the ureter, lumbar glands, meſocolon, peritonæum, and eſpecially a remarkable adipoſe branch, bent around the bottom of the kidney: and, without becoming leſs, it proceeds behind the peritonæum, as far as the ring of the abdomen. This ring is formed entirely of the tendinous fibres, deſcending from the external oblique muſcle, interrupted by a long aperture, growing wider downwards; a great many of which, ſlender and interior, are partly inſerted extenſively into the middle of the os pubis, and partly decuſſate and

and unite with the fibres of the mufcle of the oppofite fide ; thefe are called the inner column. Other external ftronger fibres, feparated from the former by the aperture, are inferted in a thick bundle into the outer fide of the os pubis, under the denomination of the external column : from it various fibres run off to the fafcia lata and groin. The upper part of this opening is in fome meafure clofed up by fibres, arifing from the outer column, inflected and afcending along the inner and weaker column. Below thefe fibres, through the fmall opening left, which is often divided by tendinous fibres, the fpermatic artery defcends, along with the vein, and vas deferens, formed into a cylindrical cord, with a good deal of cellular fubftance, before the external column, but does not perforate the peritonæum, which lies before it through its whole extent. At this ring, the ductus deferens is joined with the rope of veffels, and the whole bundle proceeds into the groin, and afterwards into the fcrotum. The fpermatic artery gives many branches to the cremafter, to the cellular coat, and to the feptum of the fcrotum ; and defcends in two plexufes to the tefticle ; of which the principal paffes betwixt the epididymis and origin of the vas deferens, to the middle and lower part of the tefticle, and is diftributed in tranfverfe branches, through the albuginea : the other plexus goes to the tefticle in company with the vas deferens, has a like termination, and is varioufly inofculated with the former. Other fmall arteries go to the coverings of the tefticle from the epigaftrics, and others from thofe of the bladder, accompanying the vas deferens ; both of which communicate with the fpermatic veffels.

DCCCXIII. Thefe very numerous arteries play about the epididymis ; but the larger of them fpread tranfverfely through the albuginea, which they perforate in feveral places, and enter into the innermoft fubftance of the tefticle, through which they are

are every where diſtributed upon the numerous membranous ſeptula. There is no larger anaſtomoſis or communication betwixt the ſpermatic artery and vein here, than in other parts, nor are the branches within the albuginea, received into the teſticle, without blood. But the long courſe of this artery, the ſmallneſs of its diameter, the ſerpentine flexures, the great proportion of the branches to the trunk, and their cold ſituation, demonſtrate, that the blood arrives at the teſticle ſlowly, and in ſmall quantity.

DCCCXIV. The right ſpermatic vein carries its blood to the cava; the left to the emulgent vein, or to both: it is enormouſly larger than the artery, both in its trunk and branches; and accompanies it, but more plentifully, having ſeveral trunks interwoven into a very long reticulated web within the abdomen, which ſurrounds the artery, and is continued into the teſticle, by degrees dividing into two like the artery. There are ſome valves in this vein, though few.

DCCCXV. The external coverings of the teſticle have their arteries from the epigaſtrics; the ſcrotum from the crural arteries, and from the internal branch of them, which is called the external pudenda; the correſpondent veins go to the ſaphæna, and to the crural veins.

DCCCXVI. The nerves of the teſticle are many, whence its ſenſibility is peculiarly acute, ſo that injuries of the teſticle are immediately followed by faintings and convulſions, and particularly by locked jaw. Some of them ariſe deep from the renal plexus, from the great meſenteric plexus, from the trunk of the intercoſtal nerve, and laſtly from the meſocolic plexus, and follow the courſe of the ſpermatic veſſels. Others, more ſuperficial, deſcend to the coverings of the teſticle, from the ſecond, third, and fourth pair of the lumbar nerves.

DCCCXVII. I have frequently obſerved lymphatic veſſels in the ſpermatic cord, which are believed to ariſe from the teſticle itſelf, and which unite with thoſe that accompany the inguinal blood-veſſels. The induſtry of late anatomiſts has traced ſome of them even to the network of the teſticle itſelf.

DCCCXVIII. The blood, moved ſlowly and in a ſmall quantity, brought by its arteries into the inner fabric of the teſticle, (DCCCXIII.) is diſtributed into minute veſſels, which carry their fluids to the ſeminal veſſels, although we are ignorant of the manner by which the arteries communicate with theſe tubes, bundles of which form the whole ſubſtance of the teſticle. Theſe are ſmall, ſerpentine, ſomewhat firm, and have a very ſmall caliber in proportion to their membranes; they are not, however, ſo impervious as to prevent them from being filled through the vas deferens. They are collected together into bundles, above twenty in number, ſeparated by cellular partitions, which deſcend from the albuginea into the teſticle, and conduct the arteries and veins. In each cell there is a duct which receives the ſemen from the ſeminiferous veſſels. Theſe ducts, twenty or more in number, form a network of longitudinal veſſels adhering to the albuginea, and inoſculate with each other; and readily permit quickſilver to eſcape into the ſurrounding cellular ſubſtance. From this net twenty or thirty ducts aſcend to the upper part of the epididymis, which being wonderfully convoluted, form as many vaſcular cones. Theſe, joined together by intermediate cellular ſubſtance, and lying upon each other, form the head of the epididymis, and in that head ſoon meet together into one duct on the outſide of the teſticle.

DCCCXIX. This ſingle duct being convoluted into an infinite number of folds and ſerpentine flexures, in a manner not found in any other part of the body,

body, and connected together by much loose cellular substance, and being collected by one continuous membrane produced from the albuginea, constitutes the epididymis. But the duct of which the epididymis is composed, grows larger as it descends; from whence being reflected, it again ascends along the posterior surface of the testicle, and by degrees unfolding its spiral convolutions, which are now much larger, it gets the name of ductus deferens. Almost always, however, a small vessel separates somewhere from the ductus deferens, and ascends along with the chord, having an uncertain termination.

DCCCXX. This is the course described by the semen, moved forwards by the fluid successively coming from the testicle, and perhaps by the cremaster; but very slowly, as we may conclude from the numberless convolutions of the epididymis, obstructing almost every kind of injection; and from the length of time that is required to repair the semen, after the seminal vesicles have been exhausted.

DCCCXXI. The cylindric ductus deferens being composed of very thick spongy substance, included betwixt two firm membranes, perforated by a very small tube, begins at the bottom of the epididymis, ascends in the chord of the spermatic vessels, passes through the ring of the abdomen (DCCCXII.) descends into the pelvis, applies itself to the bladder between the ureters, and there meets with its subjacent receptacle, which is called the vesicula seminalis, of which there are two, one right and one left. Here the vas deferens lies on the inner side of the vesicle, as far as the prostate gland; and being dilated in its course, and bent in a serpentine direction, it appears cellular. But very near the prostate, the duct, being continued from these cellular windings, unites with a conical duct coming from the vesicle, in a very acute angle, into one

 duct,

duct, alſo conical, which is continued rather from the vas deferens, and penetrates through the proſtate gland, there forms a great flexure, diverges outwardly at right angles from its companion of the other ſide, and, becoming contracted, opens into the urethra in one of the two very ſmall lateral orifices of the tumid, long beaked, hollow protuberance. By injecting a liquor into the ductus deferens of a dead ſubject, we perceive that it flows both into the urethra and into the ſeminal veſicle, but more readily into the former: but in a living perſon the ſemen never flows out but in the act of venery; and conſequently the ductus deferens conveys all its ſemen, notwithſtanding the retrograde angle, to the ſeminal veſicle.

DCCCXXII. By this laſt denomination we underſtand a membranaceous, firm inteſtine lying under the bladder, connected with it by much cellular ſubſtance: from which ten or more impervious cells proceed, ſome of which are alſo ramified and divided, but which end in impervious conical extremities. This inteſtine, with a great deal of firm cellular ſubſtance and intervening veſſels, and peritonæum lying under it, is ſo contracted, as to be collected into a ſhort ſerpentine maſs. Beſides, its external fabric is pulpy and thick, and is ſomething analogous to the ductus deferens. Its external fabric is wrinkled like the villous and reticulated coats of the biliary veſſels, villous with minute flocculi; and is ſaid to have ſmall pores and glands, with which I am unacquainted, though it certainly has various and hollow cells.

DCCCXXIII. The liquor depoſited in it, in the teſticle is yellowiſh, thin, and watery; and retains the ſame nature in the veſicle, though it becomes there more viſcid and yellow; and laſtly, in man it becomes white, when it is mixed with the liquor of the proſtate. It has a peculiar heavy ſmell, in every kind of animal; and it is the heavieſt fluid in

in the body. In water, part of it forms a thin, ſwimming pellicle, but the greater part, which is ſeemingly of a pulpy nature, ſinks to the bottom; and in the ſemen which has been long retained by continent people, ſhining globules mixed with a whiter liquor are eaſily ſeen with the naked eye. It agrees in many particulars with mucus.

DCCCXXIV. Without the conveyance of this into the womb, no animal which is of two ſexes can be fecundated. The reaſon of this was unknown, till the microſcope ſhewed, that in man, and in every other animal, the ſeminal liquor is full of living animalcules, reſembling eels, having in man a thick head, and a long and ſlender but conſpicuous tail; which are always found in healthy ſemen, from the period of puberty; but, before that time, and in thoſe who are ſterile from ſickneſs, they are abſent, and they are not found in any other animal fluid. That they are animalcules, appears evidently from their various motions, avoiding obſtacles, retrogreſſion, and change of velocity.

DCCCXXV. The real uſe of theſe animalcules has been much doubted; and we ſhall have another opportunity of conſidering the received opinion, that they are as it were the firſt appearance of the future animal. To me, in the mean time, the nature of the ſeminal animalcules ſeems to be the ſame with that of the eels in vinegar or other infuſory animals.

DCCCXXVI. That the ſemen is produced from the lymph of the blood, and that the chyle is added to the lymph appears probable from the diſpoſition to venery quickly ſupervening after eating, and being leſſened by faſting. It is compounded of the liquor of the teſticles, and of the ſeminal veſicles, which in ſome animals is more evident, and of the coagulable milky fluid of the proſtate gland. That liquor, however, only fecundates which is generated in the teſticles; as we ſee from caſtrated ani-

mals, which, though they have the ſeminal veſicles and proſtate, are yet unprolific.

DCCCXXVII. The ſeminal fluid is retained in the veſicles, excepting in the venereal act and in the illuſions of dreams. Being preſent during that whole time, according to its quantity, it ſtimulates the animal to venery. But a conſiderable part of the ſemen, and that the moſt volatile and odorous, is abſorbed into the blood, and by its addition to it produces wonderful changes, impregnating the whole animal with its ſmell, cauſing the beard, and hair upon the pubes, and horns to grow, changing the voice and diſpoſitions. For theſe do not happen in conſequence of the age of the animal, but of the ſemen, and never occur in eunichs. The growth and ſtrength of caſtrated animals are diminiſhed; but in uncut animals, the ferocity and ſtrong ſmell, diffuſed through the whole fleſh, increaſes. And from ſome examples of animals, and even of men, it has evinced a fatal irritating power, by exciting convulſions. Retention of the ſemen ſeems to proceed from the narrowneſs of the ſeminal duct, excretory duct, a ſcirrhoſity of the proſtate, and other cauſes not ſufficiently known.

DCCCXXVIII. The quantity of ſemen expelled at one time from the veſicles in man is but ſmall, eſpecially if the abſtinence from venery has been ſhort; and it is natural that it ſhould be but ſlowly produced from ſo ſmall, and that a ſubcutaneous artery. Its generation is accelerated by love, by the preſence of the beloved object; ſo that it diſtends its veſſels with a ſenſe of pain. Nature herſelf, therefore, enjoins venery for the preſervation of the human race, and likewiſe of the health of every ſound man. That it paſſes from the teſticle into the veſicles, is ſhewn by diſeaſes, in which the ductus deferens being obſtructed, a ſwelling of the teſticle has enſued. From the veſicle it does not eſcape, except during the venereal act.

DCCCXXIX.

DCCCXXIX. As the femen is fmall in quantity, that it might be projected with greater force, and to a further diftance, another humour, which is generated by the proftate, is added to it. This gland, fhaped like a heart, with the fmall end foremoft, furrounds the origin of the urethra, and contains it, though moft contiguous to the upper furface of the gland. It is a very hard and compact gland, of a peculiar fabric, not evidently conglomerate; it prepares a thick, white, bland, copious fluid, which is projected at the fame time and from the fame caufes (DCCCXL.) with the femen itfelf, into the excavations at each fide of the openings of the feminal veficles, through numerous ducts, and in the femen its white colour and vifcidity are predominant.

The urethra, although cylindrical upon the whole, has three confiderable dilatations. The firft in the proftate at the caput gallinaginis, the fecond in the bulb, and the third in the beginning of the glans. Its courfe at firft is generally horizontal, afterwards it afcends along the offa pubis, and in the male it is finally pendulous, except in the time of venery. It is a continuation of the nervous coat of the bladder, and is internally lined with a very fmooth epidermis; between which and the nervous coat there is cellular fubftance.

DCCCXXX. But is was neceffary for this urethra to be firm and ftraight, that the femen might be thrown with fome force into the diftant womb; therefore it is furrounded by a triple cavernous body. The firft, the proper cavernous body of the urethra, begins, as foon as that canal has paffed the proftate, with a thick origin, almoft like a heart; at firft it lies under the urethra, but afterwards furrounds it alfo above, but is there thinner, and accompanies it through the whole length of the penis, till the lower part terminates in the glans, while the upper part is reflected back from the extremity of

of the urethra, and, being dilated, returns in a contrary direction along the penis, and, being terminated by a broad, thinner, and round extremity, it rests upon the corpora cavernosa penis, and for the most part communicates with them by an imperfect septum. The fabric of this body is cellular, but lax, and composed rather of plates, interwoven like a net, than of fibres, and inclosed between two firm membranes.

DCCCXXXI. Into this cavernous body of the urethra, the blood is poured out from the deep seated arteries, which come from the external hemorrhoidals (DCCCXXXVI.) This is demonstrated by the injection of any kind of fluid, which easily flows from these arteries into the cellular spaces surrounding the urethra. But they are not spontaneously turgid with blood, because there are veins equally open, sufficient to carry away the effused blood. But when these veins are compressed by the powers mentioned in DCCCXXXIX. the blood is then retained within the cellular spaces, while the arteries, being stronger, continue to pour it in. Thus the blood stagnating, distends the bulb of the urethra, together with its cavernous body, and the glans itself. But this is performed generally when the other cavernous bodies of the penis, with which this of the urethra has no communication, are previously distended.

DCCCXXXII. The cavernous bodies of the penis arise from the ossa ischii, almost from their bottom, with which they are joined by a white, cellular, but very dense and firm substance; from whence inclining inwards and towards each other, they inclose the urethra, a little before its bulb, where, changing their direction, they go on parallel, and conjoined together, with the urethra lying below and between them, and terminate in the glans with an acute end, laterally surrounded by the cavernous body of the urethra. They consist of a very firm integument,

integument, and ſpongy internal fleſh, as in the urethra, (DCCCXXX.) like it alſo capable of being diſtended with blood. Between theſe cavernous bodies, there is a middle ſeptum, compoſed of firm parallel tendinous fibres, growing narrower downwards, and not continuous; ſo that the intermediate ſpaces are larger and more numerous, as they are more forward; and a free communication is left between the right and left ſpongy body. Other fibres of this kind run through the cavernous bodies, as well as the ſeptum, and are inſerted into the very firm involucrum: they prevent over-diſtention and aneuriſms of the penis.

DCCCXXXIII. Theſe cavernous bodies are ſurrounded by much very fine cellular ſubſtance; of which the part lying next the cavernous bodies is tenſe and firm, like a membrane; without it the cellular ſubſtance is very tender, continuous with that of the ſcrotum, and included within a thin ſkin without any fat, and always the more tender the nearer the ſkin it is. By inflation, it aſſumes a beautiful ſilky texture. But the glans (DCCCXXX.) is covered in the following manner by the ſkin: being continued from the penis, and reflected againſt itſelf, as in the eyelids; covered on both ſides with its proper cuticle, and filled with intermediate cellular ſubſtance, it is called the preputium, and may be drawn back, and laſtly, it is continued forwards again to the glans penis, and is there changed into a tender, ſoft, ſpongy, flocculent body, acutely ſenſible, covered with its proper cuticle, and with a depreſſed pulpy reticulum, ſpread over the reflected cavernous body of the urethra, (DCCCXXX.) and, finally, continuous with the membrane of the urethra itſelf. The prepuce is tied by a double triangular frænulum, by which the ſkin is joined to the cellular involucrum of the penis, as far as the mouth of the urethra. In the hollow which lies under the crown of the glans, and in that circle itſelf, are

ſeated

feated fimple febaceous follicles, which feparate a liniment, which, from the nature of the place, is fetid, as in other parts of the body expofed to friction. The whole penis is fuftained by a firm cellular fubftance, compacted into a kind of triangular ligament, which defcends from the fynchondrofis of the offa pubis, and is continuous with the denfe and hard cellular ftratum that furrounds the cavernous bodies.

DCCCXXXIV. The whole human penis forms a cylindrical body, depreffed on the upper part, of variable magnitude, whofe ufe is to be received into the female parts of generation, and to carry thither the prolific femen.

DCCCXXXV. Thefe cavernous bodies of the penis, during coition, by the blood impelled through the arteries, and retained in the veins, become turgid, diftended and ftiff, and fuftain the flaccid, or if it alone were filled, the weak urethra, in fuch a manner that the femen may arrive at the diftant womb. This is demonftrated from the diffection of animals killed in the act of venery, from artificial erection, from the injection of liquid fubftances into the veffels of the penis. It is produced by love, the defire of enjoyment, the friction of the glans, and various irritations of the bladder, tefticles, feminal veffels, and urethra, from urine, from abundance of good femen, from the veneреal poifon, from cantharides, whipping with rods, or nervous convulfion. But the caufe of this diftention is not yet evident. The defcription of the diftribution of the blood-veffels into the genital parts is therefore now neceffary, to fhow how little it is adapted for promoting the caufe which compreffes the veins.

DCCCXXXVI. The aorta at the fourth vertebra of the loins, and the vena cava at the fifth, are divided; of thefe the latter is pofterior, the former anterior. The common iliac branches, before they arrive at the middle interval at the beginning of the

the thighs, ſend off inwards and downwards a conſiderable artery, called the hypogaſtric, which in the fœtus is larger than the femoral artery, and in the adult is equal to it. This deſcends into the pelvis, and divides into four, five, or ſix principal branches; of which the firſt is the iliaca anterior, which alſo ſends branches to the dura mater and cauda equina, upwards to the loins, and downwards to the os ſacrum. The next, the ſacra lateralis, goes to the ſame os ſacrum and cauda equina, when it does not ariſe from the former. The third, the iliaca poſterior, is almoſt confined to the glutei muſcles. The fourth, the iſchiadica deſcendens, ſupplies ſeveral muſcles, the nerves, and the levator ani. The fifth, or the trunk, is the hæmorrhoidea infima or pudenda communis, which, within the pelvis itſelf, ſends conſiderable branches to the bladder, and to the rectum the middle hæmorrhoidal, which anaſtomoſes with the meſenterics; after which, going out of the pelvis, it creeps by the ſide of the obturator, and gives off the external hæmorrhoidals to the ſphincter and ſkin of the anus: then dividing, its internal branch ſupplies the bulb of the urethra and the proſtate; the external is again divided, and with one branch enters deeply into the cavernous body of the penis, and runs through its whole length; while, the other branch often joined with the veſſels of the bladder, runs along the back of the penis, and terminates in branches ſent to its corpora, and to the ſkin. The ſixth is the obturatrix, ſpent upon the joint of the femur and adjacent muſcles. The laſt, the umbilical artery, will be deſcribed in treating of the fœtus; in the adult it ſends ſome branches to the bladder, from its thick callous vagina. Sometimes ſeveral of theſe arteries ariſe from one common trunk. The ſkin of the penis and ſcrotum have their arteries from the epigaſtric, from the crural, and from its internal branch. Theſe external arteries

teries communicate in many places with the internal.

DCCCXXXVII. The veins, in general, correfpond with the arteries. They often come off from the iliacs in two trunks, forming a plexus with each other; then the hæmorrhoidal vein, returning around the os pubis, forms a very large plexus upon the proftate gland, with the veins of the bladder arifing in the pelvis: from which the vena penis arifes, which is often fingle, and is furnifhed with valves, determining the return of the blood to the cava. The external veins of the penis and fcrotum go to the faphæna and crural, and communicate in feveral places with the internal veins, more efpecially at the bafis of the prepuce.

DCCCXXXVIII. The lymphatic veffels of the penis, feen by very eminent anatomifts, are faid to run under the fkin of the penis. The nerves, which are very numerous, and very large, and accompany the arteries of the penis, arife from the great trunk of the fciatic nerve. But the bladder, rectum, and uterus, are fupplied by the lower mefenteric plexus, which arifes from the middle one, and defcends into the pelvis.

DCCCXXXIX. To diftend the penis, it is neceffary that the veins (DCCCXXXVII.) carrying back the blood from the cavernous bodies of the penis or urethra, be compreffed, or, at leaft, that a power be applied to the ultimate veins, which open every where into the cavernous bodies, hindering them from abforbing the blood brought there by the arteries. The firft may be in fome degree effected by the levator, drawing up the proftate and bladder; but, from the analogy of the nipples of the female breaft, of the gills of the peacock, of the blufhing of the face produced by the paffions of the mind, and of animals, all of which copulate in the fame manner, without any erector mufcle; of the erection in animals totally different in their ftructure from man,

and

and eſpecially of the very ſudden erections in birds; from the very inaction of the erector muſcles themſelves during libidinous erection, and from their unfitneſs for compreſſing the veins; it is probable, that, independently of the muſcles, the abſorption of the blood by the veins may be retarded, and that it is affected by the multitude of deep ſeated nervous nooſes, which being conſtricted by the force of pleaſure, compreſs the veins, ſo that, being rendered narrower, they return leſs blood to the trunks than what is imported by the arteries, which are not only free from any ſtricture, but at the ſame time, by the increaſe of the pulſe, are bringing the blood more quickly, which is an acceſſory cauſe. But the cauſe of this convulſion ſeems to exiſt in the nervous ſphincters, ſince the penis becomes erected, both from mechanical irritation of the nerves, and that more ſubtile irritation cauſed by the imagination.

DCCCXL. To a continued and violent erection, an expulſion of ſemen at laſt ſucceeds, which requires much greater force than ſimple erection. For the ſemen is emitted when the irritation of the nerves is arrived at its greateſt height: and in natural venery, when the cellular ſpaces of the urethra, which are later of being filled, and the continuous glands at laſt become turgid with blood, ſo that being diſtended with a large quantity of warm blood, they become ſtiff, and therefore the nervous papillæ, being erected, are violently affected by the cauſe of pleaſure. The ſeminal veſicles are evacuated by the levator muſcles of the anus, which preſs them againſt the reſiſting bladder, being excited either by voluptuous imagination alone, or by the exceſſive pruritus of the nerves of the glans, eſpecially of its lower part, in the neighbourhood of the frenum. The ſemen is never diſcharged along with the urine, in a healthy man; becauſe the expulſion of it requires the bladder to be ſhut; for, while

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lax, it affords no reſiſtance to the ſeminal veſicles. The tranſverſe muſcles ſeem to dilate the canal of the urethra for the reception of the ſemen expreſſed from the veſicles.

DCCCXLI. Soon afterwards, the ſenſible urethra being irritated by the ſemen, the powers conſtricting it are called into action. This is principally effected by the accelerator, (DCCCII.) which ſtrongly compreſſing the bulb and adjacent part of the urethra, propels the contents more ſwiftly, in proportion as the bulb exceeds in diameter the urethra. That this may act firmly, the ſphincter of the anus, and therefore alſo that of the bladder, muſt be contracted. The accelerator ſeems alſo to be the principal muſcle of erection, by compreſſing the veins of the corpus cavernoſum of the urethra. At the ſame time, the erectores penis, as they are commonly called, ariſing from the above tubercles of the iſchium, being ſtrong, and inſerted into the cavernous bodies, ſupport the penis, in a direction intermediate betwixt the tranſverſe and perpendicular. Thus the ſemen is projected into the vagina, and into the uterus itſelf, in prolific coition. This action is very violent, and comes near to a convulſion; whence it is wonderfully debilitating, and very much injures the nervous ſyſtem principally, as the maladies ariſing from thence ſeem to indicate, from the affection of the nerves, without which the ſemen cannot be expelled.

CHAP. XXVIII.

VIRGIN UTERUS.

DCCCXLII. THE uterus in woman is ſeated in the upper part of the pelvis, with the bladder before, and the rectum behind it, without adhering to either of them, and with its mouth inclining

clining a little forwards. In the female adult, it is contained within the pelvis; but in the infant, it rifes above it. In women, the peritonæum defcends from the os pubis into the pelvis, and proceeds for a confiderable way behind the bladder, to the bottom of the uterus. Then it afcends along the uterus; and a fecond time defcends on its oppofite fide, applied to it as far as the vagina, and the tranfverfe portion of the uterus, from whence, including the rectum with lunated folds, it ceafes to differ from the ftructure in man. But this fame peritonæum, coming into the pelvis from the iliac veffels, and being broader than the uterus, and adhering to its fides, and to the vagina; and being reflected along itfelf, divides the pelvis into two regions, the anterior and pofterior, like a partition, and is called the ligamentum latum. It is accurately connected with the uterus, without any intermediate fat, fo as to ferve it on all fides as an external coat. It does not hinder the uterus from being totally moveable.

DCCCXLIII. The body of the uterus is ufually diftinguifhed from its neck. The figure of the body is convex before and behind, with a degree of flatnefs, with acute edges, where its furfaces meet, converging at the fides, and moderately convex at the top. It has a peculiar fabric, of a clofe compact, firm, but fomewhat fucculent, cellular fubftance, in which we perceive mufcular fibres, efpecially in puerperal women. They are flat, and reticularly interwoven with each other, fome longitudinally difpofed along the uterus from the fundus to the os uteri, others arranged in various circles, and particularly in the fundus, and betwixt the tubes, and likewife in the neck near the mouth. In beafts, the uterus is manifeftly mufcular; and in women, likewife, it gives evident figns of a contractile nature. Its outer coat is received from the peritonæum. After repeated examinations, I have not found any mucous finufes, branching and varioufly dividing within

within the ſubſtance of the uterus, but veins ſurrounded with cellular ſubſtance, which do not collapſe. The internal membrane of the uterus is continuous with the cuticle; within the cavity, it is pulpy, and covered with ſhort flocculi; in the cervix, it is callous and valvular. The cavity of the uterus is ſmall, almoſt triangular, but bounded by lines convex inwardly; in the remaining part, it is a compreſſed cylinder. This part, which is called the cervix uteri, is cylindrical, compreſſed, and thick, and has alſo a cylindric cavity within. It is entirely rough, with callous wrinkles, extenuated to an edge, and inclined towards the vagina. Theſe recede from an anterior and poſterior line towards the ſides, and are joined by ſmaller wrinkles, in the intervals of which are mucous ſinuſes, as round globules are every where found in the upper part of the neck of the womb, filled with a very pellucid liquor, differing both in number and magnitude. It is not uncommon for the uterus to be divided by a middle projecting line. The cervix is terminated by the os internum uteri, having a tranſverſe ſlit, ſurrounded with tumid lips, drawn out into the vagina, and received within its blind extremity, projecting into it obliquely and forwards. It is full of mucus, and has mucous ſinuſes in its tumid edges.

DCCCXLIV. The triangular part of the uterus ſends out, from its lateral angles, canals, folded together by means of cellular ſubſtance, growing gradually broader, and, again a little contracted towards the extremity: their direction is at firſt tranſverſe towards the ovarium, and afterwards deſcending, but with ſome variation: they are termed the Fallopian tubes. Their external membrane is from the peritonæum; for they are included within the duplicature of the broad ligament: their internal membrane is wrinkled almoſt reticularly, mucous, and is extended to a greater length, in the form of ſpread fringes, folded longitudinally, which crown the orifice

fice of the ovarium, and are connected to the ovary. Betwixt the two membranes, is ſome ſpongy cellular ſubſtance, of a more ſlender texture than in the vas deferens. They uſually contain mucus, the origin of which is not known. There are alſo a great number of veſſels interpoſed, and perhaps ſome muſcular fibres, but the latter are more obſcure. They are ſupported by a proper fold of the peritonæum, which proceeds from the broad ligament.

DCCCXLV. The ovaries are tranſverſely ſituated in the ſame broad ligament, included in its duplicature behind the tubes, and conjoined to theſe tubes by a peculiar expanſion of the broad ligament, which is long enough to allow them a free motion. They are of an oblong figure, compreſſed on each ſide; their unconnected edge is convex, and ſemi-elliptical; but that which is connected with the ligament is ſtraight. Their peritonæal membrane is thick, and almoſt cartilaginous. Their fabric very much reſembles that of the uterus itſelf; being cloſe, white, and cellular, and without fat. The margin of the broad ligament, where it recedes from the uterus, becoming thicker, to ſuſtain the ovary, has ſomething of a ſolid ſubſtance, reſembling a ligament, but is not hollow, or a true canal.

DCCCXLVI. In the ovary even of a young girl, there are round veſicles, conſiſting of a pretty ſtrong pulpy membrane, and connected every where to the ovarium by cellular threads, which are filled with coagulable lymph; uncertain in their number, fifteen or more being found in one ovary; nor uniform in their ſize. They are remarkable bodies, being found very widely diffuſed through all animals, even in thoſe which have but one ſex.

DCCCXLVII. Laſtly, the uterus ſends forwards, from the ſame lateral angles of its triangular body, a faſciculus, compoſed of long cellular fibres and veſſels,

veſſels, which, becoming ſmaller in its progreſs, goes out of the pelvis through the ring of the abdomen (DCCCXII.) into the groin, where it ſplits into branches, and ſeparates into ſmall veſſels, which communicate with the epigaſtrics. Has it alſo long fibres propagated from the uterus itſelf? I have not ſeen them ſufficiently diſtinctly.

DCCCXLVIII. The arteries of the uterus are from the hypogaſtrics; a conſiderable branch of which the uterine, like the loweſt to the bladder in men, ariſes from the umbilical trunk, or immediately below that trunk. It goes to the lower part of the uterus, almoſt at the termination of its neck, giving branches to the uterus, bladder, and rectum, and aſcending upwards, it ſends tranſverſe inflected branches to the uterus, makes numerous anoſtamoſes with the ſpermatics, and often gives arteries to the tube itſelf. Another plexus of branches tends downwards to the vagina, running along it a conſiderable way, although there is alſo a proper vaginal artery originating likewiſe in the pelvis, and ſometimes acceſſory branches from the meſocolic. There are alſo ſeminal veſſels which have the ſame origin as in men, and deſcend with a pampiniform plexus over the pſoas muſcle into the pelvis, and divide into two plexuſes. The poſterior goes to the ovary itſelf, with many twiſted ſurculi diſtributed through its ſubſtance and among the ova. The anterior both ſupplies the tube, and deſcends to the uterus, in which it is divided into winding branches upwards and downwards, ſome going to the bladder. Another artery, the middle hæmorrhoidal, from the trunk of the pudenda communis, accompanies the vagina a conſiderable way forwards, to which, and to the bladder and rectum, it is diſtributed. Moreover, the beginning of the vagina and the clitoris, have arteries from the external hæmorrhoidal, and the clitoris, like the penis, has both deep ſeated

and

and ſuperficial arteries, alſo inoſculating with a branch from the bladder.

DCCCXLIX. The uterine veins on the whole correſpond with the arteries, originating from the trunks of the hypogaſtrics; they are both internal as the uterine, the vaginal, and middle hemorrhoidal, and external as the circumflex, and thoſe of the clitoris. But they form a remarkable plexus on each ſide, which occupies the ſides of the vagina below the clitoris. Below that, it is joined into a continued plexus with its companion on the other ſide. A plexus alſo from the external hemorrhoidal and veſical veſſels, goes to the clitoris, as in men to the penis. They have no valves, except a few in the ſpermatics, which alſo, in a very large bundle, go to the ovarium, and the alæ veſpertilionis.

DCCCL. Within the uterus itſelf the arteries terminate in exhaling branches on its internal ſurface. In the puerperal ſtate they are elongated into pendulous tubes. Thus the veins of the uterus become at that time very large ſinuſes; for they are enormouſly enlarged, and open with very large mouths into the cavity of the uterus.

DCCCLI. Lymphatic veſſels are found in the uterus of brutes, and in women more rarely, though by very eminent anatomiſts.

DCCCLII. The nerves are ſupplied from the loweſt meſocolic plexus, united with thoſe of the ſacrum, and ſending large branches to the bladder, womb, and rectum; beſides which, ſome paſs through the broad ligament to the ovarium, and others from the nerve that goes with the veſſels to the clitoris, ariſing from the ſciatic trunk. But the ovary has alſo its proper nerves from the renal plexus, ſimilar to thoſe which go to the teſticles of the male. Thus all theſe organs, from the great number of their nerves, are extremely ſenſible.

DCCCLIII. What we have hitherto defcribed is common to all ages of the female; but about the 13th year, or fomewhat later, nearly at the fame time when femen begins to be formed in the male, a confiderable change alfo takes place in the female. For, at this time, the whole mafs of blood in the female begins to circulate with an increafed force, the breafts fwell, the pubes becomes covered; and at the fame time the menfes begin to flow, by a common law of nature; although in different countries, the time and quantity of blood difcharged is different.

DCCCLIV. This difcharge is preceded by various fymptoms in the loins, heavy pains, fometimes like colic pains, with an increafed pulfe, headachs and cutaneous puftules, and a white fluid commonly flows from the uterus. For now the fleecy veffels of the uterus, which have hitherto depofited into the uterus a milky fluid, of a very white colour in the fœtus, and in young girls ferous, now begin to be turgid with blood; and at laft to pour out the red cruor itfelf into the cavity of the uterus. This continues fome days, while, in the mean time, the firft troublefome fymptoms abate, and the orifices of the uterine veffels again gradually contracting, diftil only a little ferous moifture as before. But at uncertain intervals in young girls, gradually, however, fhortening to the end of the fourth week, the fame pains return, the fame flow of blood takes place, and this period is obferved to about the 50th year; though the diet, country, and conftitution, have much influence in this refpect. Pregnancy commmonly producs a ceffation of the menftrual difcharge.

DCCCLV. That this blood is difcharged from the veffels of the uterus itfelf, is demonftrated by actual infpection of women who have died during their courfes; of living women, in whom the uterus being inverted, has diftilled the blood from the os internum:

internum: and of others, in whom, from obſtruction of the menſes, the uterus has been filled with concreted blood; and by comparing the nature of the uterus itſelf, replete with ſoft veſſels, and ſpongy with the thin, by no means villous, and callous vagina. Obſervation alſo ſhews, that this is good blood in an healthy and clean woman. However, there is nothing to prevent the blood from being diſcharged through the vagina, when the uterus is obſtructed, as in other inſtances it is through the inteſtinum rectum, and laſtly through the remoteſt parts of the body.

DCCCLVI. Since no animal certainly menſtruates in the ſame manner as the human ſpecies, (although ſome animals diſtil blood from their genitals, in the ſeaſon of their annual venery) and ſince the body of the male is free from this periodical diſcharge, the cauſe of this hemorrhagy, peculiar to the female ſex of the human ſpecies, has been an object of inquiry in all ages. From the remoteſt periods, it has been aſcribed to the attraction of the moon, which is known to raiſe the tides; by others, to a ſharp ſtimulating fluid ſecreted in the female parts, alſo the cauſe of the venereal appetite. But its being cauſed by the moon is diſproved, ſince there is not a day in which there are not many women ſubjected to this evacuation, and there are not fewer in the decreaſe than the increaſe of the moon. There is no ſuch thing as any ferment near the uterus, but every thing is bland and mucous; and venery, which expels all thoſe juices, neither increaſes nor leſſens the menſtrual flux: and women deny, that, during the time of their menſes, they have any increaſed deſire of venery, many of them at that time being rather affected by pain and languor; and the ſeat of venereal pleaſure is rather in the entrance of the pudendum than in the uterus, from which laſt the menſes flow. Laſtly, that the menſtrual blood is forced out by ſome cauſe exciting the motion of the blood

 againſt

againſt the veſſels, appears from hence, that, when retained, it has been known to break through all the other organs of the body, where no ferments were acting, the veins being even ruptured; nor is the effect of the retained blood confined to thoſe parts which pour out the venereal humour.

DCCCLVII. Nature has, in general, given women a ſofter body, leſs elaſtic ſolids, ſmaller muſcles, with a greater quantity of fat interpoſed betwixt their fibres, and ſlenderer bones, with ſmaller proceſſes. Moreover, the pelvis of the female is, in all its dimenſions, larger; the oſſa ilia more diſtant from each other; and the os ſacrum turned more backwards from the bones of the pubes, while the oſſa iſchii are ſeparated by a longer line; but above all, the angles in which the bones of the pubes meet is much larger: which differences are confirmed by the obſervations of the greateſt anatomiſts; and from neceſſity itſelf, which requires a greater ſpace for the greater number of viſcera in the pelvis. Moreover, the arteries ſupplying the uterus are very large, more ſo than in men; and their caliber is larger in proportion to their coats, and they are more lax in proportion to the veins: but the veins are, in proportion, leſs ample in the men, and of a more firm texture than in other parts of the body. From hence it follows, in the firſt place, that, in women, the blood is brought to the womb in greater quantity, and more quickly, through lax and ample arteries; and, in the ſecond place, that, on account of the rigidity and narrowneſs of the veins, it returns with difficulty from the uterus, and diſtends its veſſels.

DCCCLIX. The female infant, when firſt born, has ſmall lower extremities; and the greater part of the blood of the iliac arteries goes to the umbilicals, a ſmall portion only enters the pelvis. Hence the pelvis is ſmall, and little concave; and the bladder and uterus itſelf, with the ovaries, riſe above the pelvis.

pelvis. But, when the fœtus is born, and the umbilical artery is tied, all the blood of the iliac artery defcends into the lower limbs and pelvis, which grow larger, and the pelvis becomes deeper and wider; fo that by degrees, the womb and bladder fink into its cavity, and are not fo much compreffed by the inteftines and peritonæum, when the abdominal mufcles contract the lower parts of the belly. Then, when the growth is completed, or nearly fo, the arteries of the uterus, and of the pelvis in general, which in the fœtus were very fmall, have become very large, and are eafily injected with wax; and all things are fo changed, that the hemorrhoidal artery now forms the trunk of the hypogaftric (DCCCXXXVI.) as formerly the umbilical had done. More blood, therefore, at this time goes into the uterus, vagina, and clitoris, than formerly.

DCCCLX. At the time when the growth of the body has almoft ceafed, and a large quantity of blood is prepared in found vifcera and in healthy conftitutions, plethora takes place in both fexes of the human fpecies. In the male, it vents itfelf frequently by the noftrils, from the exhaling veffels of the pituitary membrane (CCCCLVIII.) being dilated to fo great a degree, as to pour out the red blood, and now the femen firft begins to be fecreted, and the beard to grow. But in the female, the fame plethora finds a more eafy paffage, becaufe the very weight of the blood carries it downwards, and becaufe the uterine veffels, now much enlarged, being placed in a lax fituation in the fucculent and foft cellular fubftance of the uterus, and being therefore very extenfile and exhaling by very foft flocculi, open into the empty uterus, and the blood finds almoft a more eafy paffage that way, than into the correfponding veins; while in the fame females, the arteries of the head are firmer and fmaller in proportion. The return of the blood is alfo retarded, both becaufe the flexures of the arteries

arteries, from the increafed afflux of the blood, become more ferpentine and fitter for retarding the motion of the blood, and becaufe it now returns with difficulty through the veins. The blood is, therefore, firft collected in the veffels of the uterus, which at this time, according to diffections, are turgid; then in the arteries of the loins and in the aorta itfelf; now when the heart fends a new torrent of blood into the veffels already diftended, its force is at laft propagated to the ferous veffels of the uterus, fo that they diftil at firft a copious warm mucus, then red ferum, and laftly pure blood. The fame determination of the blood to the genital parts, forces out the hitherto latent hairs, increafes the bulk of the clitoris, dilates the cavernous plexufes of the vagina, and excites the appetite towards venery. Accordingly, the quantity of the menftrual difcharge is increafed, and its firft appearance haftened by every thing that either increafes the quantity of blood in general, or determines it particularly to the uterus; fuch as joy, defire, pediluvia, a full diet, warm climate, and lively temperament of body. It is diminifhed by thofe things which diminifh plethora and the motion of the blood, as want, grief, cold atmofphere, inactivity and preceding difeafes.

DCCCLXI. When fix or eight ounces of blood have been thus evacuated, the unloaded arteries now exert their elaftic force as all arteries do, and their diameters being contracted, they only tranfmit a thin fluid as at firft. But the quantity of blood which the uterus difcharged, being reproduced by the fame caufes, it is again excreted through thefe fame paffages, rather than through any other. Nor is it neceffary to inquire, why this period is nearly menftrual; for this depends upon the proportion which fubfifts between the quantity and momentum of the blood collected, and the refiftance of the uterus, which will at laft gradually

yield.

yield. Therefore this difcharge of blood returns fooner and does not wait for the interval of a month, whenever a greater quantity of blood is determined to the uterus in plethoric or libidinous women. They ceafe entirely to flow, when the uterus, like all the other folid parts of the body, has acquired fo great a degree of hardnefs, as cannot be overcome by the force of the heart propelling the arterial blood. This hardnefs in the uterus, in the arteries and ovaries, is fhewn by the knife and by injections. Animals in general have no menfes; on account of their uteri being membranous rather than flefhy, and if the firmnefs of their veffels, which is fo great, that in thefe animals no hemorrhage, either from the noftrils, or any other part, ever occurs. In men they do not occur, becaufe in their pelvis there is no fpongy organ fit for retaining the blood; and becaufe the arteries of the pelvis are both harder and fmaller in proportion than the veins, and thus the impetus of the blood is turned afide into the lower extremities, of which in men, the growth is greater, as that of the pelvis is lefs.

DCCCLXII. Why do the breafts fwell at the fame time? Their fabric in many refpects is analogous to that of the uterus; as appears from the fecretion of the milk in the breafts, which fucceeds the birth of the fœtus, and which increafes or diminifhes in proportion as the lochial flux diminifhes or increafes; from the fimilitude of the ferous liquor, found in the uterus, to the thin whitifh milk, in thofe, who are not lactefcent, which is very apparent in animals; and from the erection of the nipples by friction, analogous to the erection of the clitoris. Therefore, the fame caufes which diftend the veffels of the uterus, likewife determine the blood more plentifully to the breafts; the confequence of which is an increafe of the conglomerate gland of the breaft, and of the furrounding fat.

CHAP.

CHAP. XXIX.

CONCEPTION.

DCCCLXIII. WE now enter upon a very difficult ſubject; to inveſtigate what internal changes take place in woman, when the germination of the life of a new being begins within her, whom, in proper time, ſhe is to bring forth. We ſhall relate, in the firſt place, therefore, thoſe things which obſervation has proved; and then ſhall add thoſe hypotheſes by which learned men have endeavoured to ſupply whatever is not learnt from experience. How few things are aſcertained on this ſubject, and how difficult they are to be aſcertained, I have learned too much by experience.

DCCCLXIV. That ſome light may appear amidſt this darkneſs, we ſhall begin with the moſt ſimple animals, and afterwards notice what nature has added in others whoſe fabric is more compounded. The ſmalleſt animals then, which have very few or no limbs, very little diſtinction of parts, very ſhort period of life, the vital functions both few and very ſimilar to each other; theſe animals bring forth young ones like themſelves, with no diſtinction of ſexes, all of them being fruitful, and none fecundating the reſt. Some of them exclude their young whom they have conceived in their bodies, through ſome opening in their bodies; from others, ſome limbs fall off, which are completed into animals of a kind ſimilar to thoſe from which they have fallen. This kind of generation is extended very widely, and comprehends the greater part of animal life.

DCCCLXV. The next, which are a little more compounded, all parturiate; yet in ſuch a manner, that in their bodies is generated a certain particle, diſ-

ſimilar

ſimilar to the whole animal, and contained in ſome involucra, within which lies the animalcule that is afterwards to become ſimilar to that within which it is produced; theſe are called eggs. A great part of theſe animals is immoveable.

DCCCLXVI. The animals which follow, which are not indeed numerous, have both eggs and alſo male ſemen; ſo that both ſexes are joined in the ſame individual. By the male ſemen we underſtand that with which it is neceſſary for the eggs to be ſprinkled, in order to become prolific, although alone it never becomes a new animal. In this claſs, therefore, a juice is prepared by its own proper organs, which is poured on the eggs generated in like manner, in proper, but different organs.

DCCCLXVII. Thoſe animals are much more numerous which have both a male juice and female eggs; and yet are not capable of fecundating themſelves, but ſtand in need of real venery. For of this kind two individuals concur in the work of fecundation, in ſuch a manner, that each impregnates the other with its male organs, and reciprocally has its female organs impregnated by the male parts of the other.

DCCCLXVIII. And now the nature of animals approaches nearer and nearer to that of the human race; amongſt the individuals of which, though in other reſpects ſimilar, ſome have only male organs, and theſe males ſprinkle their ſemen on the female eggs of others. Many cold blooded animals affuſe their ſeed upon the eggs after they are excluded from the body of the mother. Warm animals inject their ſemen into the very uterus of the female. But now, whether eggs be generated within the body of the female, and the fœtuſes be produced incloſed in coverings, or whether the female carry the live fœtus ſo long in its uterus, until it produce them without any involucrum; the difference between theſe oviparous and viviparous animals

imals is ſo ſmall, that in the ſame claſs, and in the ſame genus, ſome animals lay eggs, and others live fœtuſes; and, laſtly, the ſame animal ſometimes lays eggs, and ſometimes brings forth live young.

DCCCLXIX. From this review of animals it appears, that all of them are produced from an animal ſimilar to themſelves; many of them from a part of it ſimilar to the whole; others from an egg of a peculiar ſtructure; but that all theſe do not ſtand in need of male ſemen. Laſtly, the locomotive and more lively animals, having a compound ſtructure, only are endowed with a double ſyſtem for generation; and the difference of ſexes ſeems to be added for the bond of ſocial life, and for the preſervation of a leſs numerous progeny.

DCCCLXX. To this effuſion of the male juice into the female organs, both ſexes are excited by the moſt vehement deſires: the male indeed moſt ſtrongly; the female being always ready to ſuffer the venereal congreſs, it behoves the male to be animated with a deſire of venery, when he has abundance of good and prolific ſemen. Therefore, this circumſtance itſelf is the greateſt cauſe of venereal deſire in him; but in females, of the brute kind eſpecially, it is a certain degree of inflammation in the vagina, which excites an intolerable itching.

DCCCLXXI. But nature has added, for combining the energy of both, in women and in quadrupeds, to the uterus, a vagina or round membranous canal, very dilatable, which, embracing the mouth of the uterus, (DCCCXLIII.) deſcends downwards, and then downwards and forwards, lying under the bladder, add reſting upon the rectum to which it adheres, and, laſtly, opens under the urethra with an orifice a little contracted. This orifice, in the fœtus and in virgins, is protected from the action of the air or water, by a remarkable valvular fold, denominated the hymen, formed of the ſkin and cuticle of the vagina, probably for ſome moral purpoſe, as amongſt

amongſt all the animals I have examined, it exiſts only in the human ſpecies. It would be circular, if it were not incomplete under the urethra and even there it is not always deficient; toward the anus it is broader. Being gradually worn away by copulation, and lacerated, it at laſt diſappears. The caruncles, which are called myrtiformes, are partly the remains of the lacerated hymen, and partly the indurated extremities of the columnæ of the vagina; and, laſtly, the valves of the mucous lacunæ hardened into a kind of fleſh.

DCCCLXXII. The fabric of the vagina in women is cutaneous, and is compoſed of a firm callous cuticle, and a thick, white, nervous ſkin, in which, more eſpecially at its extremity, fleſhy fibres appear. Its internal ſurface is, in a great meaſure, rough with callous verrucæ, which, though hard, are ſenſible, and with inclined laminæ, terminated by a projecting edge, pointing downwards, and arranged ſo that they are collected into two principal columns, ſtudded as it were with theſe verrucæ, of which the uppermoſt and largeſt is extended under the urethra, and the loweſt is incumbent on the anus. From each of theſe, a valvular ſeries of ſmaller papillæ, variouſly inflected into arches, is continued till they mutually meet on both ſides. This fabric ſeems to be deſigned for the purpoſes of enjoyment, and for facilitating its expanſion. It is furniſhed with a peculiar mucus, from ſinuſes ſituated all over it, but more eſpecially in its poſterior and ſmoother ſide.

DCCCLXXIII. At the entrance of the vagina are prefixed two cutaneous appendages, called nymphæ, continued from the cutis of the clitoris, and from its glans itſelf, full of intermediate cellular ſubſtance, of a diſtendible fabric, jagged and furniſhed on both ſides with ſebaceous glands, ſuch as are alſo found in the folds of the prepuce of the clitoris. Their chief uſe, it is ſuppoſed, is to direct the urine, which

which flows betwixt them from the urethra, ſo as to turn it off from the body, which office is attended with a certain erection of the nymphæ. Theſe membranes deſcend from a cutaneous arch ſurrounding the clitoris, which is a part extremely ſenſible, and wonderfully prurient, and, like the penis, is compoſed of two cavernous bodies, ariſing from the ſame bones, and joined together, but without including any urethra. It is furniſhed with blood-veſſels, nerves, and levator muſcles, and a ligament ſent down from the ſynchondroſis of the oſſa pubis, analogous to thoſe in men: and in like manner from venery, the clitoris grows turgid and erect, but leſs in modeſt women; but from friction always.

DCCCLXXIV. The muſcle, termed oſtii vaginæ conſtrictor, ariſes on each ſide from the ſphincter of the anus, and being increaſed by an acceſſion from the os iſchium, covers the vaſcular plexus, and proceeds broadly forwards, along the beginning of the labia externa, and is inſerted into the crura clitoridis; it ſeems to compreſs the lateral plexuſes of the vagina, and to retard the return of the venous blood in both ways. The tranſverſe muſcle of the urethra, and the bundle from the ſphincter inſerted into it, have the ſame ſituation as in men.

DCCCLXXV. The female being invited either by moral love, or the deſire of pleaſure, admits the male, whoſe penis being introduced into the vagina, is rubbed againſt its ſides, until the male ſemen is ejected and thrown into the uterus. Thus, as we have obſerved of the male, (DCCCXL.) the friction of parts ſo tender and exquiſitely ſenſible, excites a convulſive conſtriction of all the parts ſurrounding the vagina. By theſe means, the return of the venous blood being ſuppreſſed, the clitoris, both the nymphæ, and the plexus ſurrounding almoſt all the vagina, become turgid, more eſpecially in

in libidinous women; the pleaſure is raiſed to the higheſt pitch: and, laſtly, though not always, or in all women, there is expelled, by muſcular force, (DCCCLXXIV.) a mucous lubricating liquor of various origin. The principal ſources of this are, in the firſt place, in the entrance of the urethra, where large mucous ſinuſes are placed in the tumid extremity of this uriniferous canal. Then, at the ſides of the urethra, in the bottom of the ſinuſes which are formed by the membranous valves being concave upwards, two or three large mucous ſinuſes penetrate into the ſubſtance of the urethra itſelf. Laſtly, at the ſides of the vagina, betwixt the bottoms of the nymphæ and the hymen, there is one opening, on each ſide, from a very long duct; which, deſcending towards the anus receives mucus from ſmall follicles.

DCCCLXXVI. But, by the ſame action which increaſes the pleaſure to the higheſt degree, and, therefore, cauſes a conflux of blood to the whole genital ſyſtem of the female, (DLXIII.) a much more important change is produced in the internal parts of the female: for, when the hot ſemen of the male penetrates into the ſenſible cavity of the uterus, which is itſelf turgid and heated with influent blood, the Fallopian tubes at the ſame time ſwell, being very full of diſtended veſſels, creeping betwixt their two coats, and now filled with a very great quantity of blood. In this ſtate, theſe tubes become red and rigid, and the fringed mouth of the tube aſcends, and is applied to the ovarium. All theſe changes are confirmed by diſſections of women, and other animals, and by morbid caſes.

DCCCLXXVII. But, in a female of ripe years, the ovary is extremely turgid, with a lymphatic coagulable fluid, with which the veſicles are diſtended. In a prolific copulation, ſome one of the riper of theſe veſicles burſts, and opens with a manifeſt cleft, and at length effuſes a clot of blood. Within this veſicle,

veſicle, after copulation, a kind of fleſh is formed, at firſt flocculent, then granulous, and like a conglomerate gland, conſiſting of many acini joined together by cellular ſubſtance; which, by degrees, becoming larger and harder, fills the whole cavity of the veſicle, and is indurated till it acquire a ſcirrhous appearance, in which, for a long time, a cleft, or the veſtage of one, remains. This is the corpus luteum, common to all warm blooded quadrupeds, in which ſome late anatomiſts have aſſerted, that there is a fluid before defloration; which, however experience does not admit, ſince there is no corpus luteum at that age. Nor is the veſicle, which becomes the human ovum, contained in the corpus as in a calyx.

DCCCLXXVIII. Moreover, in a prolific congreſs, the tube, compreſſing the ovarium, is ſuppoſed to expreſs through a fiſſure in the outer membrane, a mature ovulum, and to abſorb it, and then to tranſmit it to the uterus by a periſtaltic contraction, which begins from the firſt point of contact, and gradually forces the ovulum towards the uterus, as is very manifeſt in animals. The truth of this is certainly ſupported by the fiſſure produced in the ovarium after conception; by fœtuſes being certainly found in quadrupeds and in women, both in the ovarium and in the tube; and by the analogy of birds, in which the deſcent of the ovum from the ovarium is very manifeſt. Yet we muſt acknowledge, that a true ovum was never found, with certainty, in quadrupeds, unleſs after a long time. It is probable, that at the time of conception, the true ovum being almoſt fluid, very ſoft and pellucid, cannot be diſtinguiſhed from the mucus with which the tube is filled; likewiſe, that it is very ſmall, on account of the narrowneſs of the tube. The veſicle itſelf which was in the ovary, remains fixed in it, and becomes the covering of the corpus luteum. But the accounts of ova, ſaid

ſaid to have fallen from women during the firſt days, are not certain, and are contradicted by the ſmallneſs of the fœtus obſerved many days after conception; by the ſhape which it was firſt obſerved to have, which is always oblong, and in brutes even cylindrical; and likewiſe by the ſmallneſs of the tube.

DCCCLXXIX. Theſe things are performed with pleaſure to the future mother, and not without a peculiar ſenſation of internal motion in the tube, and of a tendency to faint. Neither is the place of conception in the uterus, into which accurate experiments ſhow that the male ſemen reaches. For the power of the male ſemen fecundates the ovum in the ovarium itſelf, as is proved by the fœtuſes being found in the ovaries and tubes; by the analogy of birds, in which, by copulation, one egg indeed falls into the uterus, but many are fecundated at once in the ovarium. Nor is this inconſiſtent with the ſmall quantity of the male ſemen, or its ſluggiſh nature, which, by eminent anatomiſts, has been thought unadapted for performing ſuch a journey. For it is certain, that the male ſemen has filled the tubes themſelves after recent impregnation, both in women and other animals.

DCCCLXXX. The uterus indeed, certainly in animals, and in women probably, is cloſed after conception, leſt the very ſmall ovum, together with the hope of the new progeny, ſhould periſh. At that time the new mother ſuffers many diſagreeable affections, which probably ariſe from the abſorption of the ſubputrid and ſubalkaline male ſemen. Conception, almoſt like the ſwallowing ſome rancid egg, cauſes nauſea, eſpecially of fleſh meat, vomiting, the eruption of ſome puſtules, and pains in the teeth. The greater inconveniences I aſcribe to the ſwelling of the uterus, compreſſing the viſcera of

of the abdomen, and to the retention of the menſes.

DCCCLXXXI. What we have hitherto ſtated, can certainly be confirmed or corrected by the teſtimony of our ſenſes. What follows is more conjectural, and more difficult, on account of the paucity of experiments, and their little agreement with each other. And, in the firſt place, it is a difficult queſtion, from whence do the rudiments of the new animal proceed? Are they derived from both parents, and mixed into one animal by a conjunction of ſeminal matter coming from the whole body; as indeed there is a reſemblance of the fœtus to both parents in animals, but eſpecially in plants, as confirmed by numerous experiments, and as the diſeaſes of parents are propagated to their children. But no ſemen has ever been obſerved with certainty in females; and innumerable examples of animals ſhow, that the ſpecies may be propagated without any mixture of ſeeds. Laſtly, the reſemblance to the father ſeems only to ſhow, that in the male ſemen there is ſome power, which can influence the form of the ſoft ſubſtance of the very minute embryo, juſt as the ſame power adds length to the pelvis in the body itſelf, dilates the larynx, and cauſes the horns to grow.

DCCCLXXXII. To the father ſome have attributed every thing; chiefly after the ſeminal worms, now ſo well known, were firſt obſerved in the male ſemen by the help of the microſcope, which are obſerved, with truth, to agree in figure with the form of the firſt embryos of all animals. But theſe animalcules are not proportionate to the number of the fœtuſes, and are not perpetual in the different tribes of animals; and they have too great a reſemblance to thoſe animalcules that are every where produced in other juices, which, though always tenacious of their own genus, are never found to grow

up

up into a totally different kind of animal, poſſeſſing limbs.

DCCCLXXXIII. Again, other anatomiſts, not leſs celebrated or leſs worthy of credit, have taught that the fœtus exiſted in the mother and maternal ovary; that the male ſemen excites it into a more active life, and likewiſe influences it variouſly, but that it finds it already exiſting and preſent. For yolks are manifeſtly found in the female ovary, even although they have not been ſubjected to any male influence. But the yolk is an appendix to the inteſtine of the chick; and derives its arteries from the meſenteric artery, and the membrane of the yolk is continued from the nervous membrane of the inteſtine, which is continuous with the ſkin of the animal. In the hen, therefore, the fœtus ſeems to be preſent along with the yolk, which is a part of it, and receives veſſels from it. Laſtly, the analogy of nature ſhows, that many animals generate eggs without any connection with a male of the ſame ſpecies, but that no male animal is ever prolific without a female. There is a continued progreſſion from the female quadruped to the oviparous, and from that to the non-oviparous. But the old animal produces the new one from part of itſelf. It is therefore certain, that the male is an appendage to that ſex which produces the fœtus from its own body; which addition is neceſſary in ſome tribes of animals, but in the greateſt number, and moſt fruitful, may be wanted. Nor can any kind of ingrafting be admitted with any degree of probability, by which the dilated navel of the maleborn animal ſhould cohere with the veſſels of the female. For this navel is much too ſmall at the time when the yolk is of conſiderable ſize; nor could the very ſmall umbilical arteries be applied to the very large yolk with any hope of a continuance of the circulation.

DCCCLXXXIV. Thus much concerning the materials. But there is as much difficulty concerning the means by which the rude and ſhapeleſs maſs of the firſt embryo is faſhioned into the beautiful ſhape of the human body. We readily reject ſuch cauſes as the fortuitous concourſe of atoms, the blind attractions of nutritive particles, and the action of ferments inconſcious of their effects. The ſoul is certainly unequal to the taſk of producing ſuch a beautiful fabric; and internal moulds, of which I never could conceive any clear idea, are to be referred to thoſe hypotheſes which the deſire of explaining thoſe things, of which we are unwillingly ignorant, has produced.

DCCCLXXXV. To me, indeed, the teſt of experiment ſeems to coincide with thoſe things which the mind itſelf foreſees will ariſe from their own cauſes. For hence, indeed, it appears to me certain, that the beautiful ſtructure of animals, ſo various, that it is always perfectly adapted to the proper and diſtinct habits and functions and manner of life of each; calculated by rules more perfect than thoſe of human geometry, and moſt evidently accommodated to foreſeen purpoſes, in the eye, the ear, and the hand, and finally, every where; can be aſcribed to no cauſe below the infinite wiſdom of the Creator. Again, the more frequently, and the more minutely, we obſerve the long ſeries of increaſe through which the ſhapeleſs embryo is brought to the perfection neceſſary for animal life, the more certainly does it appear, that thoſe things, which are obſerved in the more perfect fœtus, exiſted in the tender embryo, although the ſituation, figure, and compoſition, ſeem at firſt exceedingly different from what they appear at laſt; for an unwearied and laborious patience diſcovers the intermediate degrees by which the ſituation, figure, and ſymmetry, are inſenſibly corrected. Even the tranſparency of the primary fœtus alone conceals many things, which the

the colour afterwards added does not generate, but renders manifeſt to the eye. And it ſufficiently appears that thoſe parts, which eminent anatomiſts have ſuppoſed to be generated at a later period, and to be added to the primeval ones, were connate with theſe, though ſmall, ſoft, and colourleſs.

DCCCLXXXVI. It does not ſeem improbable, that the embryo, lying dormant during a long period, neither increaſes, nor is agitated, except by a very gentle motion of the humours, which we may ſuppoſe to oſcillate from the heart into the neighbouring arteries, and from theſe back again into the heart. But it is alſo probable, that the ſtimulus of the male ſemen excites the heart of the fœtus to greater contractions; ſo that it inſenſibly evolves the complicated veſſels of the reſt of the body by the impulſe of the fluid, and propagates vital motion through all the canals of the animal embryo; more quickly into ſome parts, and more ſlowly into others; and that from thence it happens, that ſome parts of the body of the animal ſeem to be produced very early, and others to ſupervene afterwards; and laſtly, that ſome do not ſhew themſelves until a long time after birth, as the veſicles of the ovaries, the veſſels of the male teſticles, the teeth, hairs of the beard, and horns of animals. In all animals, heat aſſiſts this evolution; in the more ſimple ones, whoſe veſſels are few, and leſs complicated in the variety of their origin, it alone effects it.

DCCCLXXXVII. Of the objections which are uſually brought, ſome are not true, as the difference of ſtructure cauſed by nævi; others ſeem to belong to cauſes depending on ſome accident, ſuch as moſt inſtances of monſters; ſome to the increaſe of ſome particular parts, occaſioned by the powers of the male ſemen; ſome to the cellular texture variouſly relaxed, ſo that it ſeems to form new parts; ſome to indurated juices. Although it is not eaſy to explain every thing mechanically, yet we ought to remem-

ber, that if indeed the new animal actually, and according to obſervation, exiſts in the egg, thoſe difficulties which are made cannot overturn things which have been truly demonſtrated, although perhaps ſome things may remain, to which, in the preſent infancy of human knowledge, we cannot yet give a ſatisfactory anſwer.

DCCCLXXXVIII. Some days after the human ovum is brought down into the uterus, we become more ſenſible of its changes. The ovum itſelf ſends out, from every part of the ſurface of its membrane hitherto ſmooth, ſoft branchy flocculi, which adhere to and inoſculate with the exhaling and abſorbing flocculi of the uterus (DCCCXLIII.) This adheſion takes place in every part of the uterus; but chiefly in that thick part which lies between the tubes, and is commonly called the fundus uteri. Thus, the thin ſerous humour of the uterus, proceeding from its arterial villi, is received into the ſlender venous veſſels of the ovum, and nouriſhes it together with the fœtus. Before adheſion, it is either nouriſhed by its proper fluid, or by abſorption, if indeed there is a time when it does not adhere.

DCCCLXXXIX. At this time, in the ovum, there are contained a great proportion of a watery fluid, coagulable by heat or alcohol, and limpid, and the fœtus, which is long inviſible, as I have never obſerved it before the 17th day, at firſt a ſhapeleſs maſs, conſiſting of mere mucus, and then cylindrical. When now ſome diſtinction of parts ſucceeds, it has a very great head, a ſmall body, no limbs, and is fixed by a flat ample navel to the obtuſe end of the ovum.

DCCCXC. From this minuteneſs the ovum increaſes in ſize, and alſo the fœtus, but in unequal proportions; for while the arterial ſerum is conveyed by paſſages, gradually more open, into the veſſels of the ovum, the fœtus itſelf grows the faſteſt, to which the greateſt part of the nouriſhment ſeems to paſs through

through the very large umbilical vein. At the ſame time, the ovum itſelf alſo grows, but ſlower, ſo that the proportion of the ovum, and the waters which it includes, to the fœtus, is perpetually diminiſhing. The flocculi of the ovum gradually diminiſh and occupy a ſmaller portion of the ovum, and are inſenſibly ſpread over with a continuous membrane, and only thoſe which ſprout out from the obtuſe end of the ovum increaſe, and are by degrees formed into a round circumſcribed placenta.

dcccxci. Such is the appearance of the ovum in the ſecond month; and after that period, it changes only in bulk. That portion of the ovum, in its upper part, next the uterus, making about a third of its whole bulk, conſiſts of a round, flat, ſucculent, fibrous, tuberous and perfectly vaſcular diſc, changed into equal and ſimilar tubercles, accurately, and often inſeparably connected, generally with the uppermoſt part of the uterus remarkable for its large veſſels, by thin cellular ſubſtance without fat collecting the veſſels, both generally, but chiefly in the circumference of the greateſt circle, and alſo by the exhaling arteries of the uterus, anſwering to the veins of the placenta, and by the arteries of the placenta, inoſculating with the large veins of the uterus. There, in the ſurface common to the uterus and placenta, a communication exiſts, by which the uterus tranſmits to the fœtus, both that ſerous liquor not unlike milk, and laſtly, as it ſeems, blood itſelf. This communication of fluids between the uterus and placenta, ſeems to be demonſtrated by the ſuppreſſion of the menſes in pregnant women, whoſe blood muſt be turned into another channel; from the loſs of blood which follows from the ſeparation of the placenta, eſpecially in a miſcarriage; and from the blood of the fœtus being exhauſted by hæmorrhagies from the mother; from hæmorrhagies that enſue from the unſecured navel-ſtring, while the placenta remains in the uterus, killing the

the mother; and, laſtly, from the paſſage of water, quickſilver, tallow, or wax, from the uterine arteries of the mother into the veſſels of the placenta, as obſerved, and lately confirmed by eminent anatomiſts. But that it is blood which is ſent into the fœtus, is evinced by the magnitude of the ſinuſes of the uterus and placenta; the diameter of the ſerpentine arteries of the uterus; the hæmorrhagy that follows the ſeparation, even the moſt gentle, of the placenta, and eſpecially by the motion of the blood, which, in a fœtus deſtitute of a heart, could only be given to the humours of the fœtus by the blood of the mother.

DCCCXCII. The remaining part of the body of the ovum, and likewiſe the convex ſurface of the placenta, are covered by an external membrane, which is villous, flocculent, reticulated, porous, eaſily lacerable, and vaſcular, reſembling a fine placenta, and is called the chorion. This alſo is connected to the flocculent and very ſimilar but ſofter ſurface of the uterus, by veſſels ſmaller than thoſe of the placenta, but manifeſtly inoſculated from the chorion into the veſſels of the uterus.

DCCCXCIII. Under the chorion lies a continuous white, opaque, and firm membrane, not vaſcular, which does not cover the part of the placenta contiguous to the uterus, but its concave ſurface contiguous to the fœtus. It coheres by cellular texture both with the chorion and amnios. The moſt ſimple name we can give it, is the middle membrane.

DCCCXCIV. The innermoſt coat of the fœtus, the amnios, is a watery pellucid membrane, very rarely having any conſpicuous veſſels, which, however, I have obſerved even in the human ſubject; extremely ſmooth, and in all parts alike; alſo extended under the placenta along with the former, and every where in contact with the waters. If there be more fœtuſes than one, either in woman or

in

in any other female, each of them has its proper amnios.

DCCCXCV. The nouriſhment of the fœtus from the beginning to the end of the conception, is without doubt conveyed through the umbilical vein. This gathering its roots from the exhaling veſſels of the uterus, (DCCCLIV.) and from the umbilical artery, with which it is manifeſtly continuous, and forming venous ſinuſes under the ſurface of the placenta, unites into a large trunk, which being twiſted in various folds, but leſs than its correſponding arteries, and being of ſufficient length to allow of a free motion; ſurrounded with cellular ſubſtance full of mucus; ſeparated by three partitions, and by the membrane which is continued from the amnios, but firmer, and known by the name of the umbilical rope; and ſwelling into ſeveral knots, enters the navel between diverging arches of the ſkin and abdominal muſcles, and proceeding to a proper ſinus of the liver, (DCXCII.) ſends the ſmaller portion of its blood through the ductus venoſus, which is ſmall and ſeated in the poſterior foſſa of the liver, to the vena cava; and tranſmits to the heart the greater part through the large hepatic branches which conſtantly ariſe from its ſulcus, and remain even in the adult, (DCXCV.) and through the branches of the cava, (DCXCVII.) continuous with theſe. The ſinus of the vena portarum, or left branch, is alſo a part of the umbilical vein, and its branches bring the blood from the placenta to the cava, while the right branch alone (DCXCV.) carries the meſenteric and ſplenic blood through the liver.

DCCCXCVI. But this is not the only uſe of the placenta: for the fœtus ſends great part of its blood to the placenta, through two very large umbilical arteries, which are the continuation of the aorta; and after giving off ſlender femorals, and very ſmall arteries into the pelvis, they aſcend reflected along the

the bladder, ſurrounded by the cellular plate of the peritonæum, and ſome fibres ſeparated from the bladder and urachus, and on the outſide of the peritonæum enter into the umbilical cord, in which, alternately ſtraight and contorted, with various windings, ſomewhat ſharper than thoſe of the vein around which they play, they arrive at the placenta, whoſe ſubſtance is entirely made up of their branches, and the correſponding veins, and lubricous cellular ſubſtance accompanying both veſſels; ſo that the acini themſelves, conſpicuous in the placenta, are convolutions of veſſels. This blood ſeems to paſs out through the arterial veſſels of the placenta into the bibulous veins of the uterus, ſo that after undergoing the action of the lungs of the mother, it returns ameliorated to the fœtus: For what other reaſon can be aſſigned for ſuch large arteries, which carry off above a third part of the blood of the fœtus?

DCCCXCVII. Is the fœtus alſo nouriſhed by the mouth? Does it drink from the cavity of the amnios, the lymphatic lubricating liquor, which is coagulable, unleſs when putrid, in which the fœtus ſwims, and whoſe origin is not ſufficiently known? Is this opinion confirmed by the analogy of chickens, which are neceſſarily nouriſhed from the contents of the egg only; by the abſence of a navel-ſtring in ſome fœtuſes; by the meconium filling the large, and part of the ſmall inteſtines; by the liquor found in the ſtomach of the fœtuſes of birds, and even of the human ſpecies, ſimilar to that which fills the amnios; by the proportionable decreaſe of the liquor amnii, to the growth of the fœtus; by coagulated fibres, found continued from the amnios, through the mouth and gullet, into the ſtomach of the fœtus; by hairs and true fæces being found in the ſtomach of the fœtuſes of quadrupeds; by the open mouth of the fœtus, which we have certainly obſerved; the gaping of the chicken, ſwimming in this liquor, and its attempts as if to ſwallow it? What

What are the fources of this lymph of the amnios? Does it tranfude through the invifible veffels of the amnios? Is it tranfmitted to it through certain pores from the fucculent chorion, which is itfelf fupplied from the uterus? On every point, numberlefs difficulties occur; but it feems more probable, that this liquor is nutritious, efpecially in the early ftages of the fœtus, and that it is derived from the uterus.

DCCCXCVIII. The excrements of the fœtus are collected during that whole time in fmall quantity, on account of the great tenuity of the nutritious fluid, percolated through the very fmall veffels of the uterus. I frequently obferve, that the bladder is almoft empty in the fœtus. However, there is generally fome quantity of urine, collected in the large and very long urinary bladder. But in a great portion of the inteftines, there is collected a green pulp, poffibly the remains of the exhaling juices; for I have feen a fimilar fubftance in other cavities, that are filled with exhaling juices, and in the vaginal coat of the tefticle.

DCCCXCIX. Is there, then, no allantois? fince it is certain, that from the top of the bladder the urachus paffes out, which is a tender canal, at firft broad, covered by the longitudinal fibres of the bladder as with a capfule; and afterwards, when thofe fibres have receded from it, it is continued flender, but hollow, for fome way along the umbilical cord; in which, however, it vanifhes. Are not the other parts, though not yet feen in the human fpecies, fupported by the very ftrong analogy of brute animals, which have both an urachus and an allantois? But a proper receptacle, continuous with the hollow urachus, fo large in quadrupeds, has not yet been obferved in man with fufficient certainty, or not fufficiently often; and thofe eminent anatomifts, who have obferved a kind of fourth veffel, continued along the umbilical cord into a proper veficle, do not confider that veffel to be the urachus,

urachus, and very lately have referred it to the omphalomefenteric genus; and in the human fœtus, the urine is feparated in a very fmall quantity: nor perhaps would it be an improbable conjecture, that fome portion of the urine is conveyed from the urachus into the funiculus umbilicalis, and its fpongy cellular fabric, and there effufed; and therefore, that, of all animals, man has the longeft umbilical cord, becaufe he alone has no allantois. It is certainly fhort, and enters into the cord, but does not feem to reach the placenta. Sometimes, in the adult, it has remained open, and has contained urine even as far as the navel.

DCCCC. In the mean time, the fœtus grows; the tubercles of the limbs gradually fhoot from the trunk; and the further moft beautiful evolution of the child advances to perfection, in a manner which cannot be defcribed here, and not yet fufficiently by anatomifts; of which, however, we muft premife a fhort account.

DCCCCI. The embryo which we firft faw in the uterus of the mother, was gelatinous, having fcarcely a definite form, of which one part could not be diftinguifhed from another. There was, however, in that gluten, a heart, the fource of life and motion; there were veffels which generated the liquor of the amnios; there were therefore umbilical veffels, and the trunks of the yolk, which it receives from the fœtus, are largeft when they firft become vifible. There was both a head and fpinal column, each of them very large, and larger in proportion than at any other time. There were likewife, without doubt, the reft of the vifcera, but in a mucous and pellucid ftate; for which reafon, they may be obferved fooner than is to be expected naturally, by rendering them opaque.

DCCCCII. But in every part of the fœtus, a very large proportion of water is mixed with a very little earth, fo that the very cellular texture is in an intermediate

intermediate ſtate between fluid and ſolid; from large drops of water being interpoſed between diſtant ſolid elements.

dcccciii. In birds, beſides this living gluten, there is the albumen, which is of a lymphatic nature; and the yolk, which is oleaginous: in man, there is a lacteous fluid, not very unlike the yolk, and coagulable lymph. That the blood is prepared from the fat by the proper powers of the fœtus, we are perſuaded from the example of birds. From it, are gradually prepared the other humours, and all of them are at firſt mild, void of taſte, colour and ſmell, and of a glutinous nature. The peculiar nature of each ſupervenes, at a later period, in ſome of them not till many years after birth, for inſtance in the ſemen.

dcccciv. The elementary ſolids, even in the adult, conſtitute much the ſmalleſt portion even of the harder parts of the human body; in the fœtus they differ from the fluids, only by a ſomewhat greater degree of coheſion, reſembling, as yet a gluten, at firſt fluid, and afterwards of greater conſiſtence. In this, the fibres, of which none were to be diſtinguiſhed in the primeval embryo, are by degrees produced, by the gluten, as it ſeems, being compreſſed between the neighbouring veſſels, part of the water expreſſed, and the earthy elements attracting each other. Theſe fibres variouſly comprehend one another, and form cellular texture, even morbidly, and intercept little ſpaces, in which a fluid is contained. Of this cellular ſubſtance, are formed the membranes and veſſels, and almoſt the whole body.

dccccv. The veſſels are prior, and exiſt, formed in the firſt appearance of the embryo. What firſt appears diſtinct, and formed in an egg during incubation, are venous circles: but theſe veins ſuppoſe arteries, by which they both receive their fluid, and the motion of that fluid. They are not generated mechanically,

mechanically, from any obſtacle to the courſe of the arterial blood. The trunks of the veins are firſt viſible, and afterwards the branches which lead to theſe trunks. If they were produced from reflected arteries, the branches would firſt be ſeen, and the trunks formed in the laſt place. Nor could the arterial blood, if repelled by an obſtacle, form thoſe moſt beautiful circles, and veſſels returning into the heart; but it would rather be irregularly diffuſed through the cellular texture. And the primeval heart would ſoon loſe its vitality, unleſs as much fluid returned to the heart by the veins, as was ſufficient to maintain its pulſations.

dcccvi. There are, therefore, in the primeval fœtus, when it firſt becomes viſible, ſome things more perfect and conſpicuous; others involved, inviſible, and very ſmall. The heart is the moſt perfect, and the only moveable and irritable part; although it is in many reſpects different from what it is in the adult. The brain is large and fluid; the veſſels formed, which appear in the back, next to the heart. We cannot yet diſtinguiſh the viſcera, muſcles, nerves, limbs; the bones themſelves, of which the firſt appearance is mucous, or the veſſels of the reſt of the body. The other portion is the abdomen, of which the umbilical capſule is an immenſe hernia.

dcccvii. To this embryo is ſuperadded motion, in man almoſt of the heart alone; and alſo in birds, whoſe formation does not take place without a heat rather greater than that of the human body: yet, without the heart, heat deſtroys, inſtead of forming the fœtus. The heart is proportionally largeſt at the very firſt, and afterwards decreaſes more and more in compariſon with the reſt of the body. Its pulſations are alſo at this time very frequent, and in the very ſoft fœtus extremely powerful, in impelling the humours, and diſtending and producing the veſſels.

dcccviii.

DCCCCVIII. To the force of the heart is oppoſed, what nevertheleſs is of ſervice in the formation of the fœtus, the viſcidity of the vital humours which unite the earthy elements. There is therefore in the embryo both an impelling force, which increaſes the longitudinal growth; and a reſiſting force, which moderates that increaſe, and increaſes the lateral preſſure, and thus the diſtention. By the force of the heart all the arteries, or for eaſineſs of expreſſion the artery, which repreſents all the reſt, with all the ſurrounding cellular texture, is lengthened out; its folds are ſmoothed out. It is alſo dilated. And the blood by its lateral preſſure makes an effort againſt the almoſt impervious branches of the arteries, fills and involves them, and ſets them off at more obtuſe angles: thus are produced ſpaces, having little reſiſtance, into which the gluten is depoſited. In the very ſubſtance of the artery, while it is every where dilated, between its imaginable ſolid threads, are prepared little reticulated ſpaces like the interſtices of a diſtended net, which are alſo adapted for receiving humours. Theſe are larger round the heart and in the head, whither the impulſe of the heart is more direct, and in the placenta: they are ſmaller in the inferior part of the body, from which the umbilical arteries ſubtract the greateſt part of the blood.

DCCCCIX. The fœtus increaſes very quickly, as is moſt evident in the example of the chick in ovo, whoſe length on the twenty ſecond day is to its length the firſt day at leaſt as 1,000,000 to 1; and the whole increaſe of bulk in the bird during the remainder of its life does not exceed the fifth part of its increaſe in the egg during the firſt day. For the fœtus has a larger and more irritable heart, veſſels larger in proportion, and likewiſe more numerous and relaxed, and its ſolid parts are mucous and diſtenſible. The breaſt is later formed, and ſurrounded

furrounded with membranes fo foft, that they cannot be feen.

DCCCCX. The embryo does not only increafe in bulk, but is remarkably altered in every particular, fo that it is brought forth totally diffimilar from what it was, when it firft became vifible. And firft it is probable, that from the production of the arteries of the limbs, the limbs connected to the fides by fome gluten are feparately evolved, and that at firft they fprout out very fhort, but afterwards become gradually longer, and divided into diftinct articulations, as the wings of a butterfly are expanded by the extenfion of a network of veffels. Thus likewife the right ventricle of the heart is expanded by the blood coming to it in greater quantity; and, being increafed by degrees, becomes equal to the left.

DCCCCXI. On the other hand, the cellular texture, from its glutinous aqueous nature, becoming gradually harder by the addition of earthy particles; by a gentle attraction contracts the parts, which were before ftraight, into various flexures; and unites the auricles to the heart, from which they were hitherto feparate. Thus the mufcles, by their action, draw out the proceffes from the bones, and dilate the fmall cavities into large cells: and likewife incurvate the bones, and varioufly modify their fhape.

DCCCCXII. Preffure has much influence: to it is attributed the defcent of the tefticles into the fcrotum, after the abdominal mufcles acquire irritability; to it the repulfion of the heart into the breaft, when the integuments of the breaft become larger: to it alfo the lengthening of the breaft, the fhortening of the abdomen, and the leffening of its vifcera, when the air received into the lungs dilates the cavity of the thorax. But even the bones are varioufly depreffed by the preffure of the mufcles, blood-veffels, and even of the very foft brain itfelf; and

and by the ſame means fleſh is changed into tendon.

DCCCCXIII. The power of derivation brings the blood into the pelvis and lower extremities, from the cloſed umbilical arteries: when the foramen ovale is contracted by the auricles drawn towards the heart, it evolves the right ventricle of the heart: when the veſſels of the yolk have occupied the whole length of the egg, and can receive no further elongation, it dilates the umbilical arteries of the chick, and produces a new membrane with incredible celerity. On the contrary, but by the ſame power, after the blood has acquired a new facility of admiſſion into any veſſels, the other parts, to which its paſſage is not equally eaſy, increaſe leſs quickly. The growth of the head is ſlower after the lower limbs have begun to increaſe.

DCCCCXIV. By the evaporation of the thinner part of a fluid, a membrane may be formed, as in the example of the epidermis: or cartilage, as happens in the bones: or bone itſelf, or ſomething of a ſtony nature, which happens very frequently in the ſhells of aquatic animals. The bones at firſt are ſoft, and of a mucous nature; then they acquire the conſiſtence of jelly; and this afterwards becomes a cartilage, without any change of parts, as far as can be obſerved.

DCCCCXV. Cartilage, however, is not ſo imperceptibly converted into bone. It never happens, without lines and furrows having previouſly marked the cartilage; without the red blood making a paſſage for itſelf into the veſſels of the bones; without theſe veſſels manifeſtly penetrating from the nutritious trunks into the interior of the bone, and impinging as it were in right lines on the cartilaginous extremity of the body of the bone, which they remove farther and farther from its middle. Round theſe veſſels are formed cellular texture and laminæ, which the veſſels themſelves ſeem to compreſs into

into a medullary tube. Laſtly, in the epiphyſis, which both remains cartilaginous, and denies entrance to the blood much longer, the red veſſels penetrate through the extreme cruſt, as alſo others which come from the exterior veſſels of the limbs. Thus alſo in the epiphyſis is produced a red vaſcular nucleus, which, being gradually increaſed by veſſels ſent out from its ſurface, converts the reſt of the cartilage into a bony nature.

dccccxvi. In theſe long bones, it ſeems evident, that their growth is owing to the arteries being elongated by the force of the heart, and gradually extended to the extremities of the bones: and that the hardneſs is owing to groſſer particles, depoſited in the cartilage, after its veſſels have admitted the red blood. But even a bony callus never becomes ſound, till newly formed red veſſels have penetrated its ſubſtance.

dccccxvii. The flat bones originate from a kind of membrane. Over this, the fibres ſpread themſelves, at firſt in a looſe network, and afterwards more denſely, having a membrane for their baſis; the pores and intervals between theſe fibres being gradually contracted and filled with a bony juice, at laſt convert it into perfect bone. In theſe bones alſo, ſtraight red veſſels, are diſtributed between the fibres.

dccccxviii. The phenomena of the formation of callus, prove, that, between the primeval fibres, an oſſeous fluid, replete with groſſer particles, is depoſited, as it exudes in ſmall drops, not from the perioſteum, but from the inmoſt ſubſtance of the bone, and gradually becomes indurated. But even chemical analyſis extracts that gluten from the bones; and in anchyloſis, it appears poured around in the manner of conſiſtent fluid, and manifeſtly fills up the chinks of the bones and intervals of the ſutures. It contains groſs earthy particles, which have been diſcovered by various experiments; and the juice of

of madder adhering to it, manifeftly diftinguifhes it by its colour.

DCCCCXIX. The periofteum covers the bones, as membranes the vifcera; and from it cellular productions follow the interior veffels of the bones: but the periofteum has neither ftraight fibres, nor the habit of alveoli or laminæ, nor red veffels, while the bone in the egg is indurating; nor does the periofteum at all adhere to the bone, except in the epiphyfis, when its bony nature is fpreading from the middle; and it is thinneft when the bone is in a cartilaginous ftate, afterwards it becomes every where complete. In the flat bones, it every where affords a bafis for the bony fibres.

DCCCCXX. Therefore the head is large, every where membranaceous, and, in the firft days of geftation, cartilaginous in few places, the mouth deep, and the jaws long; alfo, in the mature fœtus, there are the rudiments of the teeth, to which a great deal of membrane is attached: the brain is at firft fluid, and always foft; it is alfo large; and the nerves are large: the eyes are large, and the pupil is fhut by a membrane: the breaft is very fhort, but expanfile, on account of the great quantity of cartilage: the belly is large, and inclofed with membranes: the liver very large: the bile is inert and mucous: the inteftines are flowly irritable, and, when the fœtus is ripe, are full of green foft fæces: the kidneys are divided into lobes, and large, and renal capfules very large: the pelvis is very fmall, fo that the ovaries, the bladder, and Fallopian tubes project above it: the genital fyftem is denfe, not yet evolved, or fecreting its fluids: all the glands are large, efpecially the conglobate glands, and full of ferous fluid: the fkin is at firft pellucid, and afterwards covered with a foft cuticle, and febaceous ointment: the fat is gelatinous, and afterwards grumous: and the tendons foft, fucculent, and not yet fhining.

DCCCCXXI. There is a great difference betwixt the circulation of the blood in the fœtus and in the adult: that this may be underſtood, it is neceſſary to deſcribe the organs by which it is preformed. The firſt is the thymus, a ſoft looſe gland, conſiſting of many lobes, collected into two larger upper proceſſes, and two inferior ſhorter ones, which are, however, joined together by a great deal of long and lax cellular texture: this gland is large in the fœtus, and occupies a great part of the breaſt: it is ſeated in the cavity of the mediaſtinum, and in part of the neck; and is wholly filled, in its very inmoſt ſtructure, with a white ſerous liquor, which cannot be diſcovered without wounding it. In the adult, being compreſſed by the enlarged lungs, and by the aorta now become larger, it gradually diſappears. Of the uſe of this gland or its liquid, we are altogether ignorant; although all the other glands, eſpecially the conglobate ones, are alſo larger in the fœtus, as we have juſt now obſerved.

DCCCCXXII. We have ſaid, that the cavity of the breaſt is ſhort, being compreſſed by the enormous bulk of the liver; the lungs are ſmall in proportion to the heart, and ſolid ſo as to ſink in water, when completely excluded from the air, by being ſurrounded with water. Since, therefore, previous to reſpiration, the lungs cannot tranſmit ſo great a quantity of blood as they do in the adult (CCXCII. CCXCVII.) in the fœtus there are therefore other ways prepared, by which the greateſt part of the blood paſſes from the umbilical vein and lower cava, into the aorta, without entering the lungs. In the primeval fœtus there is no right ventricle of the heart; and the communication between the right auricle and the left is ſo large, that all the blood which comes by the vena cava paſſes immediately into the aorta, a very ſmall quantity excepted, which goes to the very ſmall and inviſible lungs. Afterwards, in the fœtus, now grown bigger, the lungs are indeed

deed larger, and the paſſage from the right part of the auricle into the left is narrower, ſince the auricular canal is now taken entirely within the heart, and the auricles themſelves are become much ſhorter. But yet the ſeptum, which is common to the right and left auricles, is perforated with a large foramen ovale, through which the blood coming from the abdomen, and a little repelled by the valvular margin of the right auricle, (LXXXIII.) flows in a full ſtream into the left ſinus. But by degrees the membrane of each ſinus is elevated backwards, and is connected with the pulmonary ſinus, above the oval foramen, by an upper fibre on each ſide, and then by many lower palmated ones in ſucceſſion, ſo as to cloſe up at firſt a ſmall part, and afterwards the greater part of this foramen; ſo that only a tranſverſely oval oblique paſſage is left, which remains free betwixt the round margin of the ſaid oval foramen, and the increaſing veſſel in the mature fœtus, equal to about a fifteenth part of the mouth of the vena cava.

DCCCCXXIII. That the blood takes this courſe, and that no part of it, on the contrary, flows from the left ſinus into the right, is conſiſtent with every fact. For, the column of blood in the right ſinus is very large; for it is impoſſible there ſhould be a larger, as it brings back the blood from the whole body; and the left auricle contains leſs blood than the right, as part of it flows through the ductus arterioſus, whence it is alſo much leſs than the right: moreover, the valve in the mature fœtus is ſo large, and placed ſo much to the left of the iſthmus or muſcular arch (DCCCCXXII.) that when impelled from the left ſide, the valve, like a ſhutter, cloſes up the foramen; but being impelled from the right ſide, it readily gives way, and tranſmits either blood or flatus, and even retains flatus itſelf, when blown from the right, and does not ſuffer it to return to the right ſide.

DCCCCXXIV. Moreover, but a ſmall portion of that blood which entered the right ventricle paſſes to the lungs: for the pulmonary artery, being in the fœtus much larger than the aorta, is continued in a ſtraight line into the ductus arterioſus; which is larger than the joint caliber of both the pulmonary branches, and greatly larger than the opening of the foramen ovale, and which enters into that part of the aorta which firſt comes in contact with the ſpine, under its ſubclavian branch: by which means it transfers more than half the blood of the pulmonary artery to the deſcending aorta, which muſt otherwiſe have paſſed through the left ventricle into the aſcending branches of the aorta; and this is the reaſon why the aorta in the fœtus is ſo ſmall at its coming out from the heart. By this mechaniſm, therefore, the lungs are relieved from preſſure, and a great part of the blood flows in a more direct courſe to the umbilical arteries, and the powers of both ſides of the heart are united in propelling the blood of the aorta.

DCCCCXXV. Thoſe who have aſſerted that the fœtus reſpires in the uterus, having made very few obſervations, have neglected that moſt eaſy one which is derived from the water, in the middle of which the fœtus ſwims, and likewiſe of the lungs, which in a fœtus are conſtantly heavy, and ſink in water; and, laſtly, the evident ſhortneſs of the breaſt, and ſmallneſs of the lungs. Whether it can take in air during its ſhort paſſage through the vagina, is more difficult to determine; and I ſuſpect, that in a certain ſituation, a healthy fœtus, not too much compreſſed, may ſometimes inſpire, while it is in part ſtill impacted between the parts of the mother.

DCCCCXXVI. The uterus increaſes conſtantly along with the fœtus; the ſerpentine arteries of which it is compoſed being extended, and rendered ſtraight, by the blood impelled into them; the veins being unable

unable to return the blood into their trunks compreſſed by the great bulk of the uterus, and ſwelling out into immenſe ſinuſes; and laſtly, the menſtrual blood, being retained in the uterus, and not entirely ſpent on the ſtill ſmall fœtus. Its thickneſs continues the ſame, becauſe the greater quantity of blood in the arteries and veins compenſates for the extenuation of its ſolid parts. The fundus or upper part, eſpecially, increaſes; ſo the tubes now deſcend from the middle of the gravid uterus. The uterus, therefore, riſes out of the pelvis, even as high as the colon and ſtomach itſelf, and compreſſes the abdominal viſcera, and the bladder and rectum. The os uteri in the firſt months of geſtation is drawn upwards along with the uterus, and recedes from the entrance of the vagina; after the third month, however, it again deſcends and immerges into the vagina. The ſame becoming perpetually ſhorter, projects into the impervious extremity of the vagina: for it is conſtantly becoming more tender; and, from that cartilaginous hardneſs which it has in the virgin womb, it is relaxed into a mucous ſoftneſs. Never perfectly cloſed together, it is covered and defended from the air by the mucus of the ſinuſes, and perhaps by that of the veſicles which are ſeated in the cervix uteri. Finally, the cervix, which remains long unchanged, at length, during the laſt months of geſtation, becomes likewiſe ſhort, and its opening becomes flat and broad, without length; and towards the time of delivery, is always, more open. At the ſame time, the fœtus increaſing, which in the firſt months had no certain ſituation, and about the middle of the time of geſtation, was often rolled together into a globe, ſo that the head lay betwixt the knees, ſinks its ponderous head more and more into the pelvis, and directs it towards the cervix uteri.

DCCCCXXVII. The various complaints in the uterus are now increaſed to the higheſt degree. Being diſtended

diſtended by the blood retained in it, all its nerves are irritated; for nothing is more diſagreeable to man, than exceſſive tenſion, unleſs it occurs very gradually. From the head of the fœtus, ſunk into the pelvis, the rectum, bladder, and that part of the uterus next to the neck, and the moſt ſenſible, are preſſed, and become painful: the fœtus, having acquired its full bulk, diſtends the uterus every way; and with greater uneaſineſs, becauſe, the waters being now taken away, the projecting limbs, and the head, preſs much more ſtrongly on the uterus. It is alſo thought, that the placenta itſelf, now very large, diſtends the naked internal ſurface of the uterus. From theſe cauſes, ariſe at firſt tranſient efforts of the irritated uterus, to free itſelf; and at laſt, when theſe cauſes have got to their utmoſt height, an uneaſy ſenſation is occaſioned by the impacted head of the fœtus, like that which ariſes from a collection of fæces in the rectum; by which pain, therefore, the mother is forced to attempt the birth of the child. The time of delivery arrives at the expiration of nine ſolar months, and is in the ſame manner defined in every ſpecies of animals, although by particular cauſes it may be accelerated or retarded for ſome weeks, provided theſe cauſes be aſcertained, and their power not extended too far.

DCCCCXXVIII. Tormented by teneſmus, now become intolerable, the mother exerts the whole effort of a very deep inſpiration, by which the viſcera of the abdomen being forced downwards, preſs upon the uterus, (DCCLVI.) while, at the ſame time, the womb itſelf, being contracted by its contractile force, urges the fœtus, ſo as ſometimes to exclude it, without any efforts of the mother. The difficulties of the birth, however, are evidently overcome principally by the efforts of the mother, when the mouth of the uterus, now very ſoft, ſuffers itſelf to be diſtended by the head of the fœtus. For the amnios, filled with water, protruded in the form of a cone,

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by the head of the fœtus, dilates the os internum uteri, becomes extenuated, and diftended, and burfts; the waters efcape, which lubricate the paffage of the vagina, and relax all the parts. Then the naked head of the fœtus, with the face turned towards the os facrum on account of its weight, and being urged forwards, like a wedge, dilates the os uteri; till, by a very powerful effort of the mother, the bones of the pubes being often fomewhat loofened with intolerable pain to the mother, and tremor of the whole body, the head is preffed out, and advances through the dilatable vagina, which is not very much compreffed by any bone; and the fœtus is brought forth, with difficulty even in quadrupeds, but moft difficultly in the human race, whofe fœtus has the largeft head.

DCCCCXXIX. It is natural for women to have but one child at a birth, which law they have in common with all the larger animals, except the carnivorous. Frequently, however, they have two, more rarely three, and never more than five. It is not to be doubted, that a fecond fœtus may be conceived, while the firft remains in the uterus; fince women have frequently born children, in whofe uterus a hard and offified fœtus had been long retained.

DCCCCXXX. The placenta, connected with the fundus uteri, (DCCCLXXXVIII.) is generally feparated without difficulty in a mature birth, by weaker throes of the mother, and by the art of the midwife. Thus the flocculi of the placenta are drawn out from the villi of the womb, a confiderable flow of blood takes place, and the mother is delivered of the fecundines. At the fame time, the umbilical cord is tied; for it cannot be left open in a healthy and lively child without danger; and is cut. Thus the umbilical vein is deprived of its fupply of blood, and an infuperable obftacle is oppofed to the arteries of the fame name.

DCCCCXXXI.

DCCCCXXXI. The uterus, which hitherto had been exceſſively diſtended, now contracts itſelf by the power of its elaſtic fibres, (DCCCXLIII.) ſo ſuddenly and powerfully, as often to catch the hand of the deliverer, and the placenta, if it be not ſoon looſened. Thus, the veſſels are compreſſed, alſo contracting to a leſs ſize by their own power; whence the large quantity of blood that was collected in the uterus, is expreſſed and flows out under the denomination of the lochia; at firſt pure blood, but afterwards, as the veſſels contract themſelves more cloſely, it becomes yellow, and afterwards white; and the extenſive wound of the uterus is healed, which ſoon ſhrinks to a bulk not much exceeding that of the virgin uterus.

DCCCCXLIV. But two or three days after delivery, when the firſt violence of the lochial diſcharge has abated, the breaſts ſwell conſiderably; and as in the time of geſtation they yielded a little ſerum, they now become turgid, at firſt with a ſerous, thin fluid, which is ſoon followed by the chyle itſelf. For milk very much reſembles chyle, but human milk leſs than that of other animals. It is white, thickiſh, ſweet, and replete with a very ſweet eſſential ſalt, grows ſour ſpontaneouſly, but is tempered by the addition of oil and lymph, and is compoſed of an odorous volatile halitus, a good deal of fat, water, viſcid cheeſy matter, and an earthy ſubſtance rather alkaleſcent; by faſting ſome time, from the chyle being then converted into ſerum, the milk becomes ſalt, alkaleſcent, and diſpleaſing to the infant. Like the chyle, it frequently retains the nature of ſome kinds of aliments and medicines. The cauſe of this increaſed ſecretion in the breaſts, ſeems to depend on revulſion, and to ſucceed the ſuppreſſion of that plentiful uterine ſecretion by which the fœtus was nouriſhed; as diarrhœa ſucceeds ſuppreſſed perſpiration. For it has been obſerved, that true milk has been diſcharged from other parts, and

and even through wounds. And there is beſides between the uterus and breaſts, ſome kind of nervous ſympathy, and a ſimilar fitneſs for generating a white liquor. For the uterus in infancy, and during pregnancy, manifeſtly generates it. But the inoſculations betwixt the mammary and epigaſtric arteries, though true, are ſo ſmall, that in this nothing is to be aſcribed to them.

dcccxlv. The breaſts are compoſed of a very large quantity of very ſoft and very white ſurrounding fat; and of a conglomerate convex gland, conſiſting of round, hard kernels, of a reddiſh blue colour, ſurrounded externally, and connected together, by firm cellular ſubſtance, ſeparating into ſmaller acini; which ſtructure is common to men and women. To theſe glands many veſſels are diſtributed from the internal mammaries, from the external thoracics, and laſtly from the humeral artery, all which mutually inoſculate near the nipple. The trunks of the mammary arteries, but not the mammales, inoſculate with the epigaſtric veſſels; the veins more evidently. The nerves, both large and numerous, as in cutaneous parts, are derived from the nerves placed between the upper ribs.

dcccxlvi. From the middle of this gland of the breaſt, and likewiſe from the ſurrounding fat, from an infinite number of roots, numerous, very ſlender, ſoft, white, and dilatable ducts ariſe, which converge on all ſides to the nipple in the centre, both into the circle which ſubtends its baſe, and into the area of that circle, and emerge into the root of the nipple. This is a cavernous cellular body, into which the blood may be effuſed, ſo as to cauſe erection, as in the penis. This papilla is perforated by twenty or more excretory ducts from the breaſt, called lactiferous; between which there is not any inoſculation, and which are much narrower in the nipple, than before: and in the flaccid ſtate of the nipple, are compreſſed, wrinkled, collapſed,

ſapſed, and ſhut; but when the nipple is erected by any kind of titillation, they become ſtraight and have patulent mouths, lying betwixt the cutaneous wrinkles. This papilla is ſurrounded by a circle furniſhed with ſebaceous glands, which defend the tender ſkin againſt attrition and perpetual moiſture.

DCCCCXLVII. This is the firſt food of the infant, and at other times alſo is exceedingly ſalutary to man. This the infant knows how to take, before it has attempted to perform any other function of the body. Taking the nipple in its mouth, it cauſes it to ſwell by gentle vellications, and preſſes it with the lips, that no air may enter betwixt them; at the ſame time, it inſpires and forms a ſpace in its mouth, in which the air is rarefied; and thus, the preſſure of the air, and the compreſſing force of the lips of the infant, emulges the milk from the nipple, from which, on account of its quantity, it is moreover diſpoſed to flow ſpontaneouſly; and the infant ſucks, and is nouriſhed. The firſt ſerous milk, termed coloſtra, looſens the bowels of the young infant, and evacuates the meconium, (DCCCXCVIII.) to the great advantage of the child. Yet, even independent of the fœtus, ſimple titillation erecting the nipples, and increaſing the afflux of blood, has produced a flow of milk, even from virgins, old women, and men. Milk is only generated after puberty; before that time a ſerous humour flows from the breaſt; and for the moſt part it is firſt generated about the middle of pregnancy. After the menſes have ceaſed, the breaſts, as well as the uterus, being grown effete, ceaſe to perform their office.

DCCCCXLVIII. But great changes happen to the infant when born. The firſt is reſpiration, which it attempts even within the vagina of the mother; being probably excited, by various pain and anxiety, to thoſe cries with which it ſalutes the light, and perhaps

perhaps by the desire of food which is obtained from the store of the amnios: therefore, it draws air into its lungs, and dilates them, till now, small and full of serous humours, and changes them from being of a deep red colour, small, solid, and sinking even in salt water, into a substance, which is light, spongy and floating, large, full of air, and almost of a white colour: therefore, the blood enters more easily into these enlarged and loose lungs, (cclxv.) in consequence of which, a large portion of the blood of the pulmonary artery, that went through the canalis arteriosus into the aorta, now passes into the lungs by the other branches of that artery. And the duct is still more deserted, as there is a new obstacle to the descent of the blood into the abdomen; for the very large umbilical arteries are now tied, so that the blood of the descending aorta cannot now find its way, but by an effort with which it dilates all the arteries of the pelvis and lower extremities. Finally, as the lungs receive more blood, the aorta arising from the heart also receives a greater quantity, and the intermediate ductus arteriosus is compressed between the tumid aorta and the pulmonary artery, so that in the adult it is found not only empty but shortened; in other respects it is singularly red within, soft, and very apt to concrete with stagnating blood. This course of the blood, therefore, is soon abolished, commonly within a year.

dcccxlix. Then the foramen ovale is, by the same causes, also gradually closed up. For as soon as the passage into the lungs is rendered easier, the passage into the right side of the heart also becomes easier; whence the blood of both cavas flows thither more plentifully, as it is invited by the lax pulmonary artery, and therefore does not need that passage excavated in the septum of sinuses. Again, the umbilical vein, being now almost destitute of any supply of blood, on account of the umbilicus being

being tied, (DCCCCXXX.) lefs blood will flow into the lower cava, and confequently the preffure againft the foramen ovale will be diminifhed; into which, moreover, the blood of the upper cava, on account of the ifthmus, will be fcarcely able to penetrate. Laftly, as more blood is conveyed through the lungs into the left finus, it is dilated, and, along with the whole finus, the cornicles of the oval valve, which are fixed to it, are extended, and elevate the valve; fo that, in the mature fœtus, being drawn over the ifthmus, it entirely fhuts up the paffage, and is clofely applied to the ifthmus, while, at the fame time, the blood, within the left finus, fupports the valve againft the impulfe of the blood within the right finus. Thus, by the acceffion of a little friction of the uppermoft margin of the valve againft the fuperior ifthmus, the foramen ovale clofes up by degrees, and the upper margin of the valve is agglutinated and coheres to the pofterior furface of the ifthmus. But this takes place very flowly; fo that, very frequently, even at an advanced age, a fmall aperture ftill remains between the ifthmus and upper part of the valve; and where there is no aperture, yet there are the remains of the whole foramen, hollow to the left fide, and of a paffage at the upper part, open towards the right fide, and clofed to the left, becaufe the power of the blood in the right fide is always either greater than its refiftance on the left, or certainly not lefs, even in the advance of life.

DCCCCL. The umbilical vein, being deprived of blood, foon clofes up. The blood of the vena portarum, being no longer impeded by an oppofite force coming from the umbilicus, occupies the left finus and curve of the umbilical foffa, (DCXCV.) and tranfmits blood through thofe branches by which the umbilical vein formerly fent blood into the cava. The ductus venofus being neglected, clofes by the new compreffion which the diaphragm, defcending in

in inſpiration, makes againſt the liver; by which the left lobe of the liver is preſſed towards the lobule, and perhaps too from the obtuſe angle which it makes with the left ſinus of the vena portarum; for it is certainly firſt cloſed next the vena portarum.

DCCCCLI. The umbilical arteries are cloſed up in the ſame way as other arteries uſually are when tied, by part of the blood being coagulated into a polypus, which fills up the impervious extremity, and by the blood, which meets with reſiſting membranes, diverging into the adjacent leſs reſiſting branches. Nor do I overlook the force of the abdominal muſcles, by which thoſe arteries are compreſſed againſt the full abdomen in reſpiration; or the very acute angle in which the umbilicalis, ariſing from the iliac artery, and now incurvated with it along the bladder, makes; or the ſtraight direction in which the thighs, which in the fœtus made an acute fold with the body, are now extended. Thus, theſe arteries are ſoon ſhut up, leaving only a very ſmall tube, that leads to two or three arteries of the bladder. The urachus is very quickly obliterated, from its aſcending directly from the bladder, being a very ſlender tube, having no outlet, and now neglected on account of the deſcent and permeability of the urethra.

DCCCCLII. From ſimilar cauſes the liver is gradually diminiſhed, and contracts itſelf within the ribs; and the inteſtina craſſa, from their ſlender condition in the fœtus, dilate to a conſiderable diameter, and the ſtomach is elongated; and the cæcum is formed by the weight of the fæces preſſing downwards on the right of the appendix; and the lower extremities are remarkably enlarged by the repulſion of the blood, from the umbilical arteries now tied; and the other changes take place, by which the fœtus inſenſibly advances to the nature of a perfect adult.

CHAP.

CHAP. XXX.

NUTRITION, GROWTH, LIFE, AND DEATH.

DCCCCLIII. EVEN after the child is born, it continues to grow, but always more ſlowly in proportion to its age. There are many cauſes for the perpetual diminution of its growth. Many veſſels ſeem to be obliterated, both becauſe they are compreſſed by the neighbouring torrent of ſome large artery, and becauſe the blood, now become more viſcid, coagulates. Beſides, the food being now coarſer, accumulates in the blood more earth, which, being carried through the whole body with the nutritious fluid, renders every part of it harder, bones, teeth, cartilages, tendons, ligaments, veſſels, muſcles, membranes, and cellular ſubſtance; ſo that an increaſe of hardneſs may be perceived, even by the touch. Wherefore, ſince the blood flows from the heart through fewer canals, and ſince all the parts which ſhould be lengthened or diſtended have become harder, it neceſſarily follows, that thoſe which ought to increaſe in bulk, will yield leſs and leſs to the impulſe of the heart.

DCCCCLIV. But the heart likewiſe, which is the part that is firſt conſolidated of all the ſoft ones, increaſes leſs than any other part of the whole body; and while the much more tender limbs and ſofter viſcera are diſtended, the heart itſelf grows more ſlowly, and continually bears a leſs, and at laſt an eight times ſmaller, proportion to the reſt of the body in the adult. At the ſame time, from that very denſity which it has ſo quickly acquired, it becomes leſs irritable, and is contracted leſs frequently within a given time. Thus, while the reſiſting powers are augmented, the diſtending ones are at the ſame time diminiſhed.

DCCCCLV.

DCCCCLV. There will, therefore, ſooner or later, be an end of increaſe; and this will happen ſooner, in proportion to the quickneſs and frequency of the contractions of the heart, and will approach when the cartilaginous cruſts of all the bones are now become ſo thin that they cannot yield or give way to the increaſe of the bony part. In women, the menſes ſeem to put an earlier ſtop to the growth. In cartilaginous fiſhes the growth is perpetual.

DCCCCLVI. There is no durable ſtate; for, nature from the firſt conception, tends, by a perpetual progreſs, towards decreaſe. It is ſaid, however, to take place, when there is neither any increaſe of bulk, nor yet any very viſible decreaſe.

DCCCCLVII. For we are all perpetually conſuming (CCCCXXXIV.) Nor do we only loſe the fluid parts of our bodies, but even thoſe which are reckoned the moſt ſolid. For even the bones are changed; and the teeth, which are harder than the bones, increaſe in bulk when the attrition of the oppoſite teeth ceaſes to wear them away, and, therefore, their elements are changed: even the fibres of ivory in the elephant's tooth have given way, and ſurrounded on each ſide, in curved lines, a leaden ſhot: the bony juice likewiſe is changed; ſince in ſome caſes the bones grow ſoft: in others, it forms bony tumors: even cicatrices themſelves have a manifeſt growth, for otherwiſe they would not be ſufficient, in an adult, to fill up a wound received in infancy; and a great quantity of the earthy, certainly of the animal part of our bodies, goes off by urine, as is proved by ſome diſeaſes.

DCCCCLVIII. The cauſes of the deſtruction of the ſolids conſiſt in the perpetual extenſion and retraction, which happens at every pulſation of the heart, of which there are an hundred thouſand every day, a degree of motion by which metals themſelves are worn; then in the friction of the fluids againſt the ſolids; the wearing away of all the membranes, which

which termimate with a loofe extremity, either on the furface or in the internal cavities of the body, which are fupported folely by the reft of the canal; in the alternate fwelling and collapfe of the mufcles; and in the attraction and preffure which our mufcles exert. But the parts of our body are the fooner worn away, that they confift of a great deal of gluten combined with a fmall quantity of earth; and that gluten, when it is extended, if the extenfion has been a little fuperior to the force of cohefion, muft of neceffity fall away and be carried off from the earthy parts. Thus, deficiencies are generated, fuch as are vifible in the arteries of old men. The cellular texture, which otherwife would be diffolved in water, into a jelly, is worn away by the friction produced by the impetus of the blood preffing againft the neighbouring blood-veffels and mufcles, and by the perpetual alternation of flexion and extenfion.

DCCCCLIX. This decreafe would be very quick and indeed there would be no great diftance between the end of our life and its beginning, unlefs thefe loffes were repaired. The fluid parts are reftored by the aliments, and that pretty quickly; as appears from the example of a chicken, in which blood is generated from its aliment within two days. The fat, however, and red globules of the blood, are formed out of the fat, as is fhown elfewhere; the lymphatic juice from the jelly; the mucus, from mucus; and the reft of the humours, from thefe and water. The folids are repaired almoft by the fame means which we have defcribed in the hiftory of the fœtus. A gelatinous juice is conveyed from the aliments, through the arteries, to all parts of the body, and exudes into the cellular texture every where. The furrows, which we imagine to be made in the inmoft arterial membrane by the impetus of the blood, are filled up by a vifcid matter, applied to them by the lateral pref-fure;

ſure ; never in too great quantity, becauſe the exuberant parts of the nutritious particles muſt neceſſarily be abraded by the current of the blood. Nor will it be deficient while there is a ſufficient quantity of aliment; ſince there is more reſt, and leſs reſiſtance in the bottom of the furrow, which is farther removed from the motion of the blood through the centre of the veſſel. There ſeem to be certain powers in the air, by which the aliment is attached to the ſolid parts, although we are ignorant of the manner in which they act.

DCCCCLX. The decreaſe of the cellular texture ariſing from attraction or preſſure is repaired by the viſcid vapour exhaling from the artery, and applied to the waſted places by the force of the neighbouring arteries and compreſſing muſcles, its aqueous part being expreſſed and abſorbed. The gluten repairs moſt of the organic parts, tendons, and membranes ; being formed into new cellular ſubſtance, as in the fœtus.

DCCCCLXI. The waſte, which takes place in the unconnected extremities of parts adhering by their other extremity to the reſt of the body, can be repaired by protruſion alone, while the lymph fills up the intervals produced.

DCCCCLXII. When the growth of the body can proceed no further, fatneſs ſupervenes, which is a kind of imitation of real growth. This proceeds from the fat generated by the aliment ; which, from the impetus of the blood being now leſſened as it enters the ſmall veſſels with more difficulty, is removed to the ſides of the veſſels ; enters the lateral veſſels, and inorganic pores of the arteries ; exudes into the cellular texture ; and there is accumulated, in conſequence of the diminution of the compreſſing power of the blood, and likewiſe of the abſorption by the veins.

DCCCCLXIII. The beginnings of decay are perceptible even in youth itſelf. Even in that blooming

ſeaſon the ſolid elements of the body are augmented, the apertures through which the humours flow are leſſened, the veſſels are obliterated, and the greater attraction of the cellular ſubſtance has condenſed the whole body. In every part of the body the induration produced by age becomes conſpicuous, in the bones now wholly brittle, in the ſkin, in the tendons, in the conglobate glands, in the arteries, and in the weight of every part, and of the brain itſelf. But thoſe parts grow ſooneſt rigid, which are moſt exerciſed by motion; as thoſe in every workman, which he chiefly employs in his profeſſion.

DCCCCLXIV. Moreover, the arteries continue to become denſer, narrower, and even impervious, both by the internal preſſure of the blood flowing through the large arterial tube, and by the attraction of the cellular texture of which the greateſt part of the artery is compoſed. An infinite number of parts of the cellular texture therefore ceaſe to be nouriſhed; to which the minute arteries hitherto conveyed nouriſhment; but which being now ſtopped up, bring none. The extending force being removed, the cellular flocculi attract each other, leſſen the interſtices between them, degenerate into membranes, or ſubſtances of a hard texture, which incloſe, and, as it were ſtrangulate other veſſels. The gelatinous vapour likewiſe concretes in the interſtices of the cellular texture, and forms a hard ſolid with its ſides. The muſcles, by the expulſion of their blood, and the concretion of their fibres, degenerate into hard denſe tendons, deſtitute of irritability.

DCCCCLXV. At the ſame time, the nerves become more and more callous, and inſenſible to the impreſſions of the ſenſes, and the muſcles to irritation: thus the contractile force of the heart, and the frequency of its pulſations, is diminiſhed, and therefore every force which impels the blood into the ultimate veſſels.

DCCCCLXVI.

DCCCCLXVI. The quantity of humours is diminiſhed in the denſer body, as the perſpiration, ſemen, humours of the eye, and of the conglobate glands; the vapour, which moiſtens the ſolid parts of the body, every where manifeſtly decreaſes. For this reaſon, nutrition now languiſhes, becauſe there is more which requires nouriſhment, and leſs nutritious juice.

DCCCCLXVII. Nor is the quantity of humours only diminiſhed: they themſelves likewiſe become vitiated. They were mild and viſcid in children: but theſe ſame humours are now acrid, ſalt, fetid, loaded with a great quantity of earth, in old men. This is produced by the uſe of ſalt and putreſcent aliments, the bad effects of which increaſe, being collected through a great length of time; alſo, by the diminution of the cutaneous perſpiration, and the coſtiveneſs of the belly, on account of the diminiſhed irritability, and by the reſorption of the putrid liquamen, thus increaſed. Hence the fetor of the urine, of the breath, and the difficult healing of wounds.

DCCCCLXVIII. But the greateſt fault of the humours, is, that they abound with earthy particles, both collected inſenſibly from the aliments after the ſecretions have become leſs eaſy, and partly abſtracted from the ſolids themſelves, and returned into the blood: for this earth is demonſtrated in ſome diſeaſes, and by the nature of the gouty concretions. From this abundance of earth, the proportion of that element through the whole body, is again augmented, becauſe the nutritious liquor brings too much of it along with it; whence the brittleneſs of the bones, and the hardneſs of all the parts increaſes: it is likewiſe every where depoſited in the cellular texture, and produces every where cruſts, at firſt callous, and then bony or ſtony, chiefly in the coats of the arteries.

DCCCCLXIX. The rigidity of the whole body, the decreaſe of the muſcular powers, and the diminu-

tion of the ſenſes, conſtitute old age; which, ſooner or later, oppreſſes mortals ſeverely: ſooner, if ſubjected to violent labour, or addicted to pleaſure, or fed upon an unwholſome diet; but more ſlowly, if they have lived quietly and temperately, or if they have removed from a cold to a warm climate.

DCCCCLXX. But as thoſe cauſes inceſſantly continue to operate in rendering the matter of the body more denſe, in diminiſhing its irritability, and in augmenting the quantity of earth, it is not poſſible but decrepit old age muſt ſucceed. In it, the ſenſes are almoſt deſtroyed, and the vis inſita of the muſcles becomes exceedingly weak, ſo that the limbs loſe their ſtrength, and become, eſpecially the legs, unable to direct the body; that the callous inſenſibility of the nerves cannot be excited to perform the office of generation; that the very inteſtines, becoming torpid, do not obey the habitual ſtimuli; that, by the induration of the intervertebral cartilages, the body bends forward; that by the falling out of the teeth, the jaws, now rendered ſhorter, do not ſupport the lips ſufficiently; and laſtly, that the pulſations of the heart become one half leſs frequent than in the infant ſtate.

DCCCCLXXI. Thus at laſt, the neceſſity of natural death approaches, although the greateſt number of mortals are carried off prematurely by diſeaſes. One in a thouſand exceeds the age of 90; and one or two perhaps in a century live to the age of 150. Man is long lived, when compared with other animals; he is alſo more tender than any of them, has looſer fleſh, and leſs hard bones. It is not eaſy to ſay what was the cauſe, in long lived people, of their longevity. England ſeems to exceed all other nations in the number of thoſe who live to an advanced age; and in general, the temperate countries are remarkable in this reſpect. Among the claſſes of men, the commonalty has almoſt ſolely afforded theſe rare examples; although, from its being

being the moſt numerous, we may expect a greater number of examples. Some prerogative ſeems to belong to ſobriety, at leaſt in a moderate degree; temperate diet; peaceable diſpoſition; a mind not endowed with very great vivacity, but cheerful, and little ſubject to care. Among animals, birds are longer lived: and fiſhes, whoſe heart is very ſmall, growth very ſlow, and whoſe bones never harden, are the longeſt lived.

DCCCCLXXII. Death from old age happens ſometimes, but rarely. It may be ſaid to occur, when the powers gradually decay, firſt of the voluntary muſcles, then of the vital muſcles, and laſtly, of the heart itſelf; ſo that, in an advanced age, life ceaſes through mere weakneſs, rather than through the oppreſſion of any diſeaſe. I have often obſerved the ſame kind of death in animals. The heart becomes unable to propel the blood to the extremities, the pulſe and heat deſert the feet and hands; yet the blood continues to be ſent from the heart into thoſe arteries neareſt to it, and to be carried back from thence: the flame of life is thus ſupported for a little while, which ſoon after we perceive to be extinguiſhed; when now the heart itſelf, being totally deprived of its powers, and not irritable by the blood to any effectual motion, cannot propel the blood through the lungs, that the aorta may receive its due quantity. The laſt efforts of reſpiration are now exerted to open a paſſage for the blood through the lungs, until even the powers given by nature for performing the action of inſpiration, becoming unequal to their taſk, ceaſe. Then, the left ſide of the heart neither receives blood nor is irritated, and therefore remains at reſt; while yet, for a little time, the right ventricle, and laſtly the auricle of the ſame ſide, receive the blood brought by the veins from the cold and contracted limbs, and being irritated by it, continue to beat weakly. But at laſt, when the reſt of the body has become perfectly cold, and

and the fat itſelf congealed, even this motion ceaſes, and the death becomes complete.

DCCCCLXXIII. I ſhall call that death, when the heart has become totally deprived of irritability. For the mere quieſcence of the heart is not without hope of reſuſcitation: neither does the putrefaction, or inſenſibility, or coldneſs of any part of the animal body, demonſtrate the death of the whole animal: but all theſe things, when joined together, and perpetually increaſing, with the rigidity produced by the congelation of the fat, in conſequence of reſt and cold, afford the ſigns of death in any doubtful caſe.

DCCCCLXXIV. The body after death is deſtroyed by putrefaction. Thus the fat, and the water, and the gluten, being reſolved, are diſſipated; the earth, deprived of its bonds of union, inſenſibly moulders away, and mixes itſelf with the duſt. The ſoul goes to that place which God hath appointed it: its indeſtructibility by death is proved by a very common phenomenon; for many people, when their bodily powers are waſted and ſpent, give evident proofs of a highly ſerene, vigorous, and even cheerful mind.

I N D E X.

CHAP. I.

FIBRE. CELLULAR SUBSTANCE.

1. ELEMENTARY parts.
2. General ſtructure of the the ſolids.
3. Fibres.
Their moſt fixed particles earthy.
4. The earthy particles cohere by means of interpoſed gluten.
5. Gluten is formed of oil and water.
6. Simple fibres.
7. Viſible linear fibres.
8. Laminæ.

CELLULAR SUBSTANCE.

9. General ſtructure of cellular ſubſtance.
10. Membranes, veſſels, and tunics, are formed of cellular ſubſtance.
11. The veſſels of the tunics are an acceſſion to the cellular ſubſtance.
12. Cellular ſubſtance is found every where.
13. Inorganic gluten.
14. Fibres and cellular ſubſtance are formed of gluten.
15. In what manner the ſolids are formed of gluten.
16. Varieties of cellular texture.
Where ſhort and tender.
17. Where lax.
18. The fat is effuſed into the latter.
19. The ſanguiferous veſſels of the cellular ſubſtance.
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It alſo exudes through their ſides.
20. It is abſorbed by the veins.
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21. All the cells communicate with each other.
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28. Externally, this is more lax, and perforated with blood-veſſels and nerves.
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30. The muſcular coat is formed of circular fibres.
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34. The ſtrength of the arteries.
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35. Arteries go to all parts.
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36. The proportion of the ſolid part of the artery to its caliber.
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    The angles at which the branches go off.
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39. The tranſition of the ultimate arteries into veins.
40. The various diſpoſition of the arteries in the viſcera.
41. The arteries terminate in veſſels of a ſmaller denomination.
42. Or in excretory ducts.
43. Or in exhaling canals.
44. Are veſſels every where produced from the red ones?
45. Are ſmaller orders of veſſels produced by a multiplied diviſion?
46. The veins are ſimilar to the arteries in many reſpects, but in others are different.
47. The ſtructure of the veins.
48. The ſize and diviſion of the veins.
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49. The valves of the veins.
50. The veins originate from arteries; from veins of inferior orders; from the abſorbing veins of the whole circumference, and of every cavity of the body.
51. Other abſorbing veſſels from the cellular texture are little different from theſe.
52. There are veins as well as arteries of ſmaller kinds.
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59. The blood moves rapidly through all the veffels.
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60. Proofs that all the arteries and veins communicate.
61. The blood flows through the arteries from the heart to the extremities.
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63. Harvey firft fhowed, that the venous blood every where returned from the extremities to the heart.
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162. The velocity of the blood coming from the heart muſt continually be diminiſhed as it proceeds farther through the arteries.

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163. The blood does not ſeem to loſe ſo much of its velocity as, according to calculation, it ought to do.

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166. The pulſe is the meaſure of the powers of the heart.

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170. It moves more quickly in the trunks than in the branches.

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172. The venous blood is propelled by the action of the muſcles.

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177. The effects of the motion of the heart and arteries upon the blood, and by what means they are eſtimated.

178, 179. The means by which we underſtand the manner in which theſe effects are produced.

180. The friction which takes place in the arteries.

Its effects, how calculated.

Whence the redneſs of the blood.

181. Does the heat of the blood ariſe from its motion?

182. The progreſſive motion of the blood hinders putrefaction.

183. It is various in different particles of different natures.

184. The effects of the ſyſtole of the arteries.

185. The ſmalleſt mouths of the arteries are the moulds in which the particles of blood are formed.

186. What is the uſe of the reticulations of the arteries.

187. The effects of a retarded motion of the blood.

CHAP. VII.

SECRETION.

188. Four claſſes of ſecreted humours.

The firſt conſiſts of the coagulable ones, which for the moſt part exhale.

189. The ſecond are not coagulable, and partly exhale, and partly do not.

190. The third are mucous.

191. The fourth inflammable.

192. The other humours are compoſed of theſe.

193. A deſcription of the ſecretory organs is required, in order to diſcover the reaſon of the diverſity

diverſity of the ſecreted fluids in the different organs.
194. The ſecretion of coagulable liquors is performed without glands.
195. What glands ſecrete the albuminous fluid of the joints.
196. The ſeat of theſe glands.
197. The exhaling liquors which are not coagulable are ſecreted without glands.
198. Such liquors as are neither coagulable nor exhaling, are ſecreted by conglomerate glands.
Theſe are compoſed of acini.
199, 200, 201. The ſtructure of theſe acini.
202. Some liquors of the nature of 198 are even ſecreted without theſe kernelly glands.
203. The mucus is every where ſecreted by glands.
The ſtructure of a true gland.
204. How the ſecretion is performed in theſe glands.
205. The excretory orifices.
The cryptæ.
206. The conglutinated glands.
207. The excretory ducts.
208. The compound glands.
The agminated or congregate glands.
209. The various ſecretions of inflammable liquors.
There are many ſebaceous glands without a duct.
210. Other ſebaceous ones have a duct.
211. Compound ſebaceous ones.
212. The milk is ſecreted in conglomerate glands.
213. The organs being deſcribed, we return to the queſtion 193.
214. The blood going to the ſecretories is already of a particular nature.
215. The retardation of the blood in the minute veſſels ſeparates the more denſe humours from thoſe that are lighter and more ſluggiſh.
216. The mouths of the ſecretory veſſels are of very different diameters.
217. This inequality may alter the ſecretions in many different ways.
218. Moſt ſecretions are performed by veſſels ariſing from ſanguiferous arteries.
Others, however, by veſſels which ariſe from an inferior order of arteries.
219. The angle at which the ſecretory branch goes off is perhaps of ſome conſequence.
What things render this probable.
What things render it doubtful.
220. The flexions of veſſels contribute to ſecretion.
221. The denſity of the arteries may do the ſame.
Their irritability has nearly ſimilar effects.
222. Various circumſtances which augment or diminiſh the velocity of the blood have great effect on the ſecretions.
223. The ſecreted humours are varied by a variation of theſe conditions.
224. The largeſt and denſeſt particles of the blood paſs into the veins.
225. What becomes of the large, ſlow, and ſluggiſh particles.
And of the coagulable ones.
226. In what veſſels the thin and aqueous liquors are ſecreted.
In what veſſels the light aqueous but viſcid and ſlow humours.
227. Various hypotheſes are formed concerning ſecretion.
228. It remains to be diſcovered how the pure ſecretions are made.
All recent ſecretions have an admixture of water.
229. All of them become viſcid by ſtagnating in follicles.
230. The fluids may be changed in their receptacle by the admixture of a new liquid.
231. The reſorbed humours are alſo of uſe.
232. The uſe of receptacles.
233. The powers by which the retained humours are at laſt ejected.

CHAP. VIII.

RESPIRATION.

234. The figure of the lungs.
235. The external membrane of the lungs.
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238. Its muſcular fibres.
239. Its mucous glands.
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240. The veſſels and nerves of the aſperia arteria.
241. Its diviſion into bronchia.
242. Their ultimate branches terminate in cellular texture.
243. The bronchial arteries & veins.
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The pulmonary veins.
245. The lymphatic veſſels of the lungs.
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246. A very large portion of the blood enters the lungs.
The utility of this viſcus depends on the air.
247. The nature of atmoſpherical air.
248. In what manner it is excluded from the body.
We muſt inveſtigate why it enters the lungs.
249. The reaſon why it enters them.
250. The general fabric of the thorax.
251. The vertebræ of the back.
252. The articulation of the ribs with the vertebræ.
The ligaments of this articulation.
253. How the ribs are joined with the ſternum.
254. The length of the ribs.
255. The direction of the ribs.
Their ſtrength various.
256. The ſternum.
257. The thorax muſt be raiſed in order to dilate the ſeat of the lungs.
This is performed by the external intercoſtal muſcles.
258. The internal intercoſtals.
There are doubts concerning the action of theſe, but it is certain that they elevate.
259. In what manner the thorax is enlarged by theſe.
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260, 261. The diaphragm.
262. The two holes of the diaphragm.
263. The contraction of the ſeptum augments the capacity of the thorax.
Alone, it almoſt performs reſpiration.
264. By what powers it is aſſiſted in deep inſpirations.
265. Inſpiration, how performed.
Its effects on the air and blood-veſſels.
266. Is air contained between the lungs and thorax?
267. The air is vitiated by reſpiration.
268. The inconveniencies of too long an inſpiration.
269. The powers of expiration.
270. The abdominal muſcles conſpire to produce this effect.
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271. What powers aſſiſt the muſcles in ſtronger reſpirations.
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273. From thence there ariſes a new neceſſity for inſpiration.
274. Other cauſes for alternate reſpiration are ſcarcely aſcertained.
275. Reſpiration is neceſſary for adults.
276. The utility of reſpiration is different from that neceſſity.
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279. Is the blood condenſed in the lungs?
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What

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281. What ſeem to prove the contrary.
282. Is the blood cooled in the lungs?
283. Does the red colour of the blood proceed from the air?
285. Is the uſe of the blood to abſorb nitre from the air?
286. What animals live long without air.
Why every animal dies in air that is not renewed.
287. What is the connection between the pulſe and reſpiration.
288. Cough.
289. Laughter.
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Sneezing.
290. The acceſſory uſes of reſpiration.

CHAP. IX.

VOICE AND SPEECH.

291. The larynx is compoſed of cartilages.
Its veſſels and nerves.
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293. The annular cartilage.
294. The arytenoid cartilages.
295. The glottis.
296. The epiglottis.
297. The ventricles of the larynx.
298. The mucous glands of the larynx.
299. The thyroid gland.
300. The connection of the larynx with the os hyoides.
The elevation of the larynx, and contraction of the glottis.
301. The depreſſion of the larynx, and dilatation of the glottis.
302. The cavity of the mouth.
The noſtrils.
303. The tongue.
304. The voice.
Whiſpering.
305. The ſtrength of the voice.
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306. A grave tone is produced by the oppoſite cauſes.
307. The cauſes of diverſity of tone.
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CHAP. X.

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312. The arch of the aorta, and the branches produced from it.
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The external carotid. From it proceeds,
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The labial.
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314. The occipital artery.
The auricular.
315. The temporal artery.
The internal maxillary.
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Other branches of the internal maxillary.
316. The internal carotid.
Its flexures.
Its paſſage through the foramen of the os petroſum.

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The branches produced from it in the receptacle.
317. The branches of the internal carotid on the bridge and crura of the brain.
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The anterior and poſterior branch.
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318. The vertebral artery.
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The profunda cerebri.
319. The concluſions which may be deduced from the hiſtory of the arteries of the brain.
320—324. The coverings of the brain.
320. The oſſeous ſhell of the encephalon.
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321. The external and internal lamina of the dura mater.
The falx and tentoria proceed from theſe; their uſe.
322. The glands.
323. The arachnoid membrane.
324. The pia mater.
325—339. The veins of the encephalon.
325. The fourth ſinus.
326. The ſuperior ſinus of the falx.
The tranſverſe ſinuſes.
327. The inferior ſinus of the falx.
328. The inferior, anterior, and poſterior veins of the brain.
329. The veins of the cerebellum.
The ſuperior veins terminate in the fourth ſinus; the inferior ones in the ſuperior petrous and tranſverſe ſinuſes.
330. Circular ſinus.
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331. The ſuperior ſinus petroſus.
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The poſterior occipital ſinus.
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333. The uſe of the ſinuſes.
334. The connection between the arteries and the ſinuſes.
335. The blood chiefly flows into the jugular veins.
Their cerebral and facial branches.
336. The external jugular vein.
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337. The ſinuſes of the medulla ſpinalis.
338. The uſes of the venous anaſtomoſes.
339. The lymphatic veſſels of the brain.
The reſorption of what is exhaled in the brain.
340. A great number of parts are comprehended under the name of encephalon.
The cerebrum, cerebellum, bridge, and medulla oblongata, what they are.
341. The figure of the brain.
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342. The minute ſtructure of the brain.
343—53. The interior anatomy of the brain.
343. The oval ſection of the brain.
The corpus calloſum.
344. The anterior or three-horned ventricle.
345. The corpora ſtriata.
The thalami of the optic nerves.
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The mamillary eminences.
346. The pellucid ſeptum.
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347. The choroid plexus.
348. The third ventricle.
349. The pituitary gland.
350. The poſterior double commiſſure.
351. The ſeparation of the third ventricle from the calamus ſcriptorius.
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352. The nates.
The teftes.
The pineal gland.
353. The crura of the brain.
354. The cerebellum.
355. The bridge.
The medulla oblongata.
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356. The common properties of the nerves of the brain.
357. The origins of each of the nerves of the brain.
358. The medulla fpinalis.
Its pia mater, arteries, and veins.
359. The arachnoid membrane of the medulla fpinalis.
360. The hard membrane of the medulla fpinalis.
The denticulated ligament.
361. The common properties of the fpinal nerves.
362. The anterior and pofterior trunks of the fpinal nerves.
The intercoftal nerve.
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The phrenic nerve.
The acceffory nerve.
364. The extremity of the nerves.
The ftraightnefs of the fibres of the nerves.
The nerves are fcarcely elaftic, and not at all irritable.
The number of nerves is in proportion to the parts to which they are fent.
The anaftomofes of the nerves.
Ganglions.
365. How it is proved that fenfation is owing to the nerves.
It is the medullary part of the nerve which feels.
366. The foul perceives in the brain; not immediately by the fenforia and branches of the nerves.
367. How the mufcles are affected by compreffing or irritating the nerves.
368. What derangements of the animal motions happen on injuring the brain or fpinal marrow.
369. From what is laid down in 367 and 368, the nerves are proved likewife to be the organs of motion.
370. Is there in the brain any principal feat in which is the origin of all motions, and the end of all fenfation, where the foul refides ?
It is not in the corpus callofum.
371. Neither is it the proper province of the cerebellum to carry on the vital motions.
Nor are the motions called animal and vital to be referred to different fources.
372. The feat of the foul is where the nerves firft begin.
373. The nerves are the organs of fenfation and motion, not by their membranes, but by their medullary part.
374. What the medulla is.
375. Whether the medullary fibres are folid.
376. The nerves are entirely devoid of elafticity.
377. Motion can only be propagated downwards.
From what is faid, it follows, that the medullary fibre feems to be hollow.
378. Refutation of the objections againft this.
379. The nature of the nervous fluid.
How proved not to be electrical.
380. The nature of that fluid is neither aqueous nor albuminous.
381. Of what kind the nervous fluid ought to be.
382. How it is rendered more probable that the nervous fluid paffes through hollow tubes than through the fpongy and folid fubftance of the nerve.
383. The motion of the nervous juice is twofold.
384. The fame nerves moft evidently ferve both for fenfe and motion.

385. What becomes of the nervous fluid.
Whether it nouriſhes.
386. Queſtions concerning the uſes of the parts of the brain.
387. The offices of the ventricles.
388. What is known concerning the uſe of the tubercles.
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CHAP. XI.

MUSCULAR MOTION.

391. The dead power of the fibre.
392. The reaſon why it is called dead.
Its effects.
393. The characters of the dead power.
The characters which are peculiar to the red muſcular fibre.
It is neceſſary to examine its ſtructure.
394. What muſcular fibres and muſcles are.
395. The fibres treated more fully.
396. The belly, tendon, aponeuroſis, and capſule of a muſcle, what.
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Muſcles which commonly have no tendons.
The parts in which the muſcles chiefly terminate in long tendons, and thoſe to which they affix themſelves.
397. The modes in which the tendons unite themſelves with the fleſh.
A pennated muſcle, what.
398. The arteries, veins, lymphatics, and nerves, of the muſcles.
399. The ſtructure of the ultimate fibre, which is the elementary part of the muſcle.
400. There is a threefold force in the muſcle.
The vis inſita of the muſcle.
401. The meaſure of the ſhortening of the muſcles when they contract.
402. Other things which relate to the vis inſita.
403. The nervous power of the muſcle.
404. In what the nervous power and vis inſita differ.
405. The phenomena in the motion of the muſcles ariſing from the nervous power and vis inſita.
406. What the arteries contribute to the motion of the muſcles.
407. A refutation of the manner in which the nerves are ſaid to move the muſcles.
408. The nervous fluid ſeems to perform the office of a ſtimulus; and its moving cauſe is not the ſoul, but a law derived from the Creator.
409. What things ſhow that in the motion ariſing from the vis inſita, the ſoul does not interfere.
410. The difference between the muſcles obeying the will, and thoſe which are governed by the vis inſita.
411. The magnitude and loſs of the powers which the muſcles exert in their contractions.
412. The reaſon of theſe loſſes.
413. The effects of antagoniſts, as they are called, in muſcular motion.
414. Other helps to this motion.
416. The co-operation of the muſcles.
417. The effects produced by the action of the muſcles.
418. The relaxation of a muſcle at reſt.
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419. Senfation.
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421. Touch in another and more proper fenfe.
422. The true fkin.
423. The granulation and papillæ of the fkin.
424. The epidermis.
425. The rete Malpighianum.
426. Of what the network and epidermis confift.
427. The glands of the fkin.
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428. The hairs.
429. The nails.
430. The fubcutaneous cellular texture in very few places is without fat.
What purpofe it ferves after it has received the fat.
The fkin and Malpighian mucus, and epidermis, where they feem perforated, are drawn inwards, and degenerate.
431. The mode of touch, and the qualities which are known by it.
432. The Malpighian mucus, hairs and nails, what purpofes they ferve.
433. The vapour perfpiring through infinite little arteries of the fkin.
434. The ways of demonftrating this exhalation.
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437. Another element of perfpiration, fomething volatile, of an alkaline nature.
438. The quantity of perfpiring liquid.
439. The indication from the quantity of perfpiring liquid.
What things augment or diminifh it, and what follows from thence.
440. How fweat benefits or hurts the body.
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443. How it is proved that both the exhaling and inhaling veffels may be contracted and relaxed by the power of the nerves.

CHAP. XIII.

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445. The tongue in general.
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446. The fungiform papillæ.
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Others which intervene.
447. The nerves of the tongue.
448. The arterious and nervous villi which run between them.
449. The covering of the tongue.
450. The mufcles of the tongue.
451. The veffels of the tongue.
452. The manner of exercifing the tafte.
Flavours, and their caufe.
453. What things contribute to the perception of taftes.
454. The fpirits are refumed either into the papillæ or the abforbing villi of the tongue.
455. The ufe of the fenfe of tafte.

C H A P. XIV.

SMELL.

456. The ufe of fmell.
457. Smell is exercifed by the help of the membrane of the noftrils.
The nerves of that membrane.
458. The arteries and veins of the membrane of the noftrils.
459. What the noftrils are.
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460. The uppermoft, middle, and loweft offa fpongiofa.
461. The finufes in general, what they are.
The frontal finufes.
462. The ethmoidal finufes.
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464. The mucus of the noftrils.
The finufes abounding in mucus can evacuate it in the different fituations of the body, fo that fome of them can always empty themfelves.
465. The nofe and its mufcles.
466. The manner of exercifing the fenfe of fmell.
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467. The ftrength of odours.
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C H A P. XV.

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468. The reafon of the difference between the organ of hearing and that of the other fenfes.
469. The external ear and its parts.
470. The glands and mufcles of the ear.
471. The meatus auditorius.
472. The fkin and cuticle of the meatus.
The glands for feparating its wax; the wax.
473—477. The phyfical properties of the air.
474. Tones.
475. The velocity of found.
476. Sympathetic tremors.
The ftrength of found.
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477. How found rebounds from hard bodies.
The caufe of the increafe and diminution of founds.
478. The collection of founds in the meatus auditorius.
479. The membrane of the tympanum.
The founds ftrike upon it after their ultimate reflection in the meatus auditorius.
480. The tympanum.
481. The four little bones of hearing are placed in the tympanum.
The malleus.
482. The mufcles of the malleus.
The effects of the rupture of the membrane of the tympanum.
483. The incus.
484. The ftapes and its mufcle.
485. The little round bone.
486. Various canals go out of the cavity of the tympanum.
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487. The

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488. Two other paſſages lead from the tympanum into the labyrinth.
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The veſtibulum.
489. The ſemicircular canals.
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491. The veſſels of the organ of hearing.
492. The nerves belonging to this organ remain to be deſcribed.
The ſeventh pair of nerves, and its hard portion.
The nerves of the external ear.
493. The ſoft branch of the ſeventh pair of nerves.
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496. What things are known with more certainty concerning this matter.
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CHAP. XVI.

SIGHT.

498. The difference between ſight and hearing.
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499. The eyebrow.
500. The eyelids.
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The nerves and arteries of the palpebræ.
501. The tarſus.
The levator muſcle of the upper eyelid.
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502. The eyelaſhes.
503. The Meibomian ſebaceous glands.
504. The tears and their ſources.
505. The duct of the lachrymal gland.
The effects of the contraction of the orbicular muſcle.
506. What becomes of the tears.
The caruncula lachrymalis.
The third palpebra.
The punctum lachrymale.
507. The ductus lachrymalis.
The lachrymal ſac.
The naſal duct.
508. The figure of the eye.
The orbit.
The ſurrounding fat.
509. The optic nerve.
Its courſe.
510. What becomes of it, after it touches the eye.
511. The ſclerotica.
The cornea.
512. The choroides.
The Ruyſchian lamina.
The ciliary circle.
The pupil.
The iris.
The uvea.
The membrane ſhutting the pupil in the fœtus.
513. The motion of the iris.
514. The ciliary ligaments.
515. The retina.
516. The humours of the eye.
The vitreous humour.
517. The cryſtalline lens.
518. The aqueous humour.
The chambers of the eye.
519. The ſtraight muſcles of the eye.
520. The oblique muſcles of the eye.
521, 522. The nerves of the eye.
521. The ophthalmic branch of the fifth pair.
522. The branches of the third pair.
523. The motion of the ciliary proceſſes.
524—527. The arteries of the eye.
528. The veins of the eye.
529. Light in general.
530. Light conſiſts of rays of different colours.
531. Whence the colours proper to every body ariſe.
Opaque bodies, what.

532. What

532. What refraction is, and its laws.
533. When rays fall on a convex ſpheric body, which of them are refracted, and which reflected.
The focus of refracted rays.
534. What rays falling upon the cornea are reflected, or being refracted are ſuffocated, or reach the lens.
535. How the rays are refracted in their paſſage through the cornea and aqueous humour.
536. How they are refracted by the cryſtalline humour.
538. How they are refracted by the vitreous humour, and are at laſt collected upon the retina.
539. Whether objects are rather painted on the choroides.
540, 541. How the eye is thought to accommodate itſelf to the various diſtances of objects.
542. But nothing of this kind happens.
543. Myopia.
544. The cure for this diſorder.
545. Preſbyopia.
546. The remedy for preſbyopia.
547. A medium between ſhort and long ſightedneſs is beſt.
548. In what manner we judge of the magnitude of objects.
549. The force of the light, and its effects.
550. How the place of an object is eſtimated.
551. Diſtance.
552. How we perceive objects to be gibbous.
553. In what manner we judge of the ſituation of the parts of objects.
554. The images of objects remain for a little time, even after the objects themſelves are removed.
555. Various queſtions concerning viſion.

CHAP. XVII.

INTERNAL SENSES.

556. Senſation takes place when a new perception ariſes in the mind by the percuſſion of a nerve.
The perception is not the image of the object affecting the nerve.
The connection between the changes in the nerves and the perceptions produced by them in the mind, is arbitrary.
Why, notwithſtanding this, what we perceive of this world is not falſe.
557. What things are combined when we perceive.
558. The changes produced by objects in the nerves remain a long time in their origin.
The preſervation and order of theſe ideas.
559. Imagination, what it is.
560. Memory.
561. At what times of life the memory and imagination flouriſh, and when they decay.
562. Thought; attention.
Judgment; genius.
The ſources of error.
563. Soundneſs of judgment, on what it depends, and by what it is impaired.
564. What ideas moſtly affect the will.
565. The affections of the mind.
Effects of the affections of the mind.
566. The cauſes of theſe effects.
567. The paſſions of the mind are faithfully expreſſed in the countenance.
Phyſiognomy, whence it ariſes.
568. Conſent of parts, whence it ariſes.

569. The nature of the ſoul is different from the body.
570. The ſoul, however, is moſt intimately connected with the body.
571. We have no reaſon to be aſhamed of our ignorance of the manner of this connection.
572. By what arguments thoſe are chiefly perſuaded who derive the origin of all the motions and actions in the body from the ſoul.
573, 576. What circumſtances do not permit us yet to adopt that opinion.
577. Watching.
Sleep.
578. Dreams.
With theſe, ſome voluntary motions are ſometimes conjoined.
579. What actions continue to be carried on during ſleep.
580. How the mechanical cauſe of ſleep is to be diſcovered.
The phenomena of watching and of ſleep.
581, 584. What things contribute towards ſleep, or produce it.
585. The proximate cauſe of ſleep.
586, 587. This is confirmed by the cauſes of watching, and what theſe cauſes are.
588. The ſeat of ſleep is not in the ventricles of the brain.
Why the vital actions go on in the time of ſleep.
589. The effects of ſleep.
590. Various queſtions concerning ſleep.

CHAP. XVIII.

MANDUCATION, SALIVA, AND DEGLUTITION.

591. Moſt kinds of food need manducation.
592. Therefore moſt animals are furniſhed with teeth.
Their ſtructure in general.
593. In man, on account of their diverſity of food, there are different kinds of teeth.
The inciſors.
594. The canine teeth.
595. The grinders.
596. The teeth are fixed in the jaw-bones.
The various motions and articulations of the lower jaw.
597. The levators of the jaw.
The pterygoideus externus.
598. How the jaw is depreſſed.
599. The powers of the levator muſcles.
The muſcles producing a lateral and circular motion of the jaw.
600. The cheeks.
The lips.
The mouth.
The ſituation and mobility of the tongue in the mouth.
601. The liquor poured upon the aliments during maſtication.
Its ſources.
The ductus inciſivus is impervious.
602. The ſaliva.
603. The parotid gland.
The gland called the acceſſory gland.
604. The maxillary gland.
The ſublingual gland.
605. Theſe being compreſſed in maſtication, pour out their liquor.
Appetite alone alſo produces the ſame effects with compreſſion.
606. The aliments are triturated with ſaliva and air into a paſte.
They are rendered ſapid.
The volatile parts are reſorbed.
607. The motions of the tongue for revolving the aliment within the cavity of the mouth.
608. The tongue is directed by the os hyoides.

The

The mufcles depreffing the os hyoides.
609. The mufcles raifing the os hyoides.
610. The mufcles of the cheeks and lips.
611. The aliment being chewed is applied to the tongue, and carried towards the fauces.
612. How the food is carried from the mouth into the fauces.
How the accefs into the larynx is clofed.
613. The pharynx.
614. The mufcles dilating the pharynx.
615. How food is prevented from falling into the larynx.
The velum of the palate.
The uvula.
616. How the return of the aliment into the mouth is prevented.
How the epiglottis and uvula are erected after they have been depreffed.
617. The powers which prefs the aliments downwards through the pharynx.
The action of the arytenoid mufcles.
618. The mucus of the pharynx, and its various fources.
619. The tonfils.
The mucus of them is very vifcid.
The neighbouring parts are full of mucous organs.
The mucus of the œfophagus is more fluid.
The veffels of the tonfils, pharynx, and œfophagus.
619.* The œfophagus.
620. The paffage of the aliment through the œfophagus.
621. The conftriction of the upper orifice of the ftomach.

CHAP. IX.

THE ACTION OF THE STOMACH ON THE ALIMENTS.

622. The fituation, figure, and fize of the ftomach.
623. The vifcera in the neighbourhood of the ftomach.
624. The external membrane of the ftomach.
The firft cellular coat.
625. The mufcular coat of the ftomach.
The ligaments of the pylorus.
626. The fecond cellular coat.
The nervous coat of the ftomach.
The third cellular coat.
The villous coat.
The valve of the pylorus.
The pores of the villous coat.
627. The arteries of the ftomach.
628. The diftribution of the arteries through the coats of the ftomach.
629. The veins of the ftomach.
630. The nerves of the ftomach.
631. The lymphatic veffels of the ftomach.
632. The inorganic pores.
633. The mucus anointing the villous membrane.
The limpid humour which the arteries diftil.
634. The preffure of the diaphragm and mufcles of the abdomen on the ftomach.
635. The neceffity of meat and drink.
636. The phenomena of hunger.
637. New chyle, its ufes.
638. The caufe of hunger.
639. The feat of thirft.
How it is excited.
How quenched.
640. The pleafure of taking food.
641. Our diet ought to confift of two kinds of aliments blended together.
642. Why flefh is required.
643. Why vegetables.
644. Drink.
645. Condiments.
646. Preparations of aliments.
647. The meafure of food.
648. The changes which happen to the food in the ftomach.
649. What hinders the food from degenerating into complete acidity in the ftomach.

There

There is no kind of ferment here.
650. The periftaltic motion of the ftomach propelling the aliment into the inteftines.
651. The more powerful force of the diaphragm and abdominal mufcles.
In what order and time the aliments go out of the ftomach.
652. A certain portion of drink is abforbed in the ftomach into the veins.
653. Vomiting.
654. Order of arrangement.

CHAP. XX.

The OMENTUM.

655. The peritonæum and its extent.
656. The cellular texture placed round the peritonæum is continued into the capfules.
Its connection with other parts.
657. The productions and ligaments of the peritonæum.
By the feparated laminæ of the peritonæum the vifcera are furrounded, and kept firm and defended in motions and concuffions of the body.
658, 659. The mefocolon.
660. The mefocolon and mefentery are hollow.
The flender purfes of the mefocolon.
661. The mefentery.
662. What things are found in all parts of the mefentery and mefocolon.
663. Many parts are comprehended under the name of omentum.
Their nature in general.
The membrane from the external membrane of the colon inferting itfelf into the fiffure of the liver.
The natural orifice, and common porta of the omentum.
664. The leffer hepatico-gaftric omentum.
665. The anterior lamina of the greater gaftro-colic omentum.
666. Its pofterior lamina.
667. The omentum colicum.
668. It is common both to the omentum and mefentery to accumulate fat.
How it is proved that this fat is received into the veins.
669. The arteries of the omenta.
670. The nerves of the omenta.
671. The arteries of the mefentery and mefocolon.
672. The veins of the omentum and mefentery.
The lymphatic veffels of the omentum.
673. Other ufes of the omentum.
674. The ufe of the mefentery.
675. The nature of the water abforbed by the veins of the mefentery, and what it contributes towards the bile.

CHAP. XXI.

The SPLEEN.

676. The fubftance of the fpleen.
Its figure.
Connection.
Its fituation, bulk, and number.
677. The arteries and veins of the fpleen.
678. The lymphatic veffels of the fpleen.
679. Its nerves.

680. Its internal ſtructure.
Its furrounding membrane.
681. The ſpleen contains a great deal of blood.
Its nature.
682—3. The uſe of the ſpleen.
684. Conjectures concerning it.

CHAP. XXII.

THE PANCREAS.

685. The pancreatic juice.
686. The ſituation and figure of the pancreas.
Its ſtructure.
Its veſſels.
Its nerves.
687. The pancreatic duct.
688. The quantity of pancreatic juice.
The powers by which it is expelled.
The univerſality of the pancreas is an argument of its utility.
Whence the effervefcence with the bile ariſes.
688.* The utility of the pancreatic juice.

CHAP. XXIII.

THE LIVER, GALL BLADDER, AND BILE.

689. The bulk of the liver.
The ſituation of the liver in reſpect to the diaphragm.
The ligaments from it.
Other ligaments.
How it can be moved.
Its common membrane.
690. How the liver is ſituated with reſpect to the colon, kidneys, duodenum, ſtomach, and pancreas.
691. The ſhape of the liver.
692. The furrows of the liver.
Its lobes.
693. The arteries of the liver.
694. The umbilical vein.
The ductus venoſus.
695. The large trunks of the vena portarum.
696. The capſule of the vena portarum.
The diviſions of its branches.
Theſe are perpetually accompanied by branches of the hepatic artery.
The proportion of the branches of the vena portarum to the trunks.
697. The branches of the cava.
The proportion of its branches to thoſe of the vena portarum.
The trunk of the vena cava.
The ſmaller veins creeping over the ſurface of the liver.
698. The paſſage of the blood through the vena portarum.
699. The nerves of the liver.
700. The lymphatic veſſels of the liver.
701—3. The internal ſtructure of the liver.
704. How it happens that the bile is not ſecreted from the hepatic artery, but from the vena portarum.
705. How the ſecreted bile is ſent into the biliary ducts and through them.
706. The ſtructure of the biliary duct.
Its irritability and ſenſibility.
707. The ductus choledochus.
708. The ductus cyſticus.
The gall bladder.
Its ſituation.
709. The ſhape of the gall bladder.
The wrinkles of the ductus cyſticus.

710. The

710. The coats and muciferous pores of the gall bladder.
The exhalation of the arteries into the gall bladder.
The bile exudes through inorganic pores.
711. In man, no ducts come from the liver into the gall bladder.
711.* The bile flows into the intestine both from the liver and from the gall bladder.
All the bile is not first conveyed to the gall bladder.
The quantity of bile.
How often the bile flows into the bladder.
The gall bladder does not secrete its proper bile.
712. The return of bile into the blood is morbid.
713. The change which the bile undergoes in the cystis.
It is directed into the gall bladder, when there is no use for it in the intestines.
714. The powers which express the bile from the gall bladder.
715. The qualities, elements, and offices of the bile.
716. Whither the bile goes.
It sometimes comes into the stomach.
The bile of the fœtus.
Its coagulation and uses.
717. The proper use of the liver in the fœtus.

CHAP. XXIV.

The SMALL INTESTINES.

718. The small intestines in general.
Their division.
719. The duodenum.
In it chiefly the bile and pancreatic juice are mixed with the aliments.
720. The situation of the rest of the small intestines in general.
721, 27. The structure of the small intestines.
721. The external coat.
The first cellular coat.
722. The muscular coat.
723. The second cellular coat.
The nervous coat.
The third cellular coat.
The villous coat.
Its folds.
724. The villi of the intestines.
725. The vesicles of the villi.
726. The larger pores of the villous coat leading to the mucous glands.
727. The lesser pores likewise depositing mucus.
728, 730. The arteries of the small intestines.
730. The arteries of the duodenum.
731. The veins of the small intestines.
How it is proved that these absorb a thin humour from the intestines.
732. The nerves of the small intestines.
733. The liquid flowing from the arteries into the cavity of the intestines.
Its quantity.
The uses of the mucus of the small intestines.
734—5. The peristaltic motion.
736. The changes which the food undergoes in the small intestines.
737. The office of the small intestines in general.
738. The principal causes which change the aliments in the small intestines.

CHAP. XXV.

The LARGE INTESTINES.

739. The remains of the food after the chyle is extracted.
740. How the ileum applies itſelf to the colon.
The valve of the colon.
741. The blind extremity of the colon.
The appendix.
How the change from the ſtructure of the cæcum in the fœtus to that of the adult takes place.
The fetor of the inteſtines begins chiefly there.
742. The ſituation and connections of the colon.
743. The ſtructure of the colon in general.
Its ligaments.
744. The cells of the colon.
The wrinkles, follicles, and pores of its villous membrane.
745. The veſſels of the large inteſtine.
746. The diviſion of the veſſels to the large inteſtines.
The exhalation and reſorption from theſe.
The hemorrhoids.
747. The lymphatic veſſels of the large inteſtines.
Chyle is ſometimes obſerved in theſe.
748. The nerves of the large inteſtines.
749. The fæces of the inteſtinum colon.
The periſtaltic and antiperiſtaltic motion of the colon.
Flatus.
750. How the ileum is ſhut.
The paſſage of the fæces thro' the colon.
751. The ſituation and courſe of the rectum.
752. The external and muſcular coat of the rectum.
The internal ſphincter of the anus.
753. The villous coat of the rectum.
Its folds, and mucous glands.
The ſebaceous glands of the anus.
754. The external ſphincter of the anus, and its action.
How the anus is naturally cloſed.
755. The levator muſcles of the anus.
756. The excretion of the fæces.
757. The fæces themſelves.

CHAP. XXV.*

The CHYLIFEROUS VESSELS.

758. The nature of the chyle.
759. The abſorption of the chyle, and its paſſage through the lacteal veſſels.
In what animals lacteal veſſels are found.
How they are diſpoſed in the different inteſtines.
760. The valves of the lacteals.
The cauſes of the motion of the chyle through the coats of the inteſtines.
776. The glands of the meſentery.
The chyle proceeds from the inteſtines to theſe glands.
762. What happens to the chyle in the glands of the meſentery.
763. The courſe of the lacteals from the meſenteric glands to the receptacle of the chyle.
764. How the paſſage of the chyle into the receptacle is demonſtrated.
765—6. The thoracic duct.
767. The chyle paſſes to the blood through the thoracic duct.

768. The

768. The caufes of the motion of the chyle in general.
769. The change of the chyle during its circulation with the blood.
In the inteftines there are not lacteal and lymphatic veffels of different kinds.
770. The lacteal veffels abforb water when digeftion does not go on.
The thoracic duct brings back the lymph of the whole body.

CHAP. XXVI.

THE KIDNEYS, BLADDER, AND URINE.

771. A part of the water brought into the blood with the chyle is ftrained through the kidneys.
772. The fituation and connection of the kidneys.
Their figure.
External membrane.
Their fat.
Ligaments.
773. The arteries of the kidneys.
774. The veins of the kidneys.
The quick paffage of the blood from the arteries into the veins.
The veins of the renal fat.
775. The lymphatic veins of the kidneys.
776. The nerves of the kidneys.
777. The renal capfule.
778—80. The internal ftructure of the kidney.
778. The ftructure of the cortical part.
The uriniferous veffels.
The glands.
779. The papillæ of the kidneys.
780. The infundibula.
The pelvis.
781. The fecretion of urine.
The quantity of the urine.
782. The elements of the urine.
783. How the ureter carries the urine forwards.
The ureter itfelf.
784. How it is proved that the urine is fecreted in the kidneys, and defcends by the ureter into the bladder.
785. The urine cannot defcend by other paffages.
786. The fituation of the urinary bladder.
787. The figure and magnitude of the bladder.
788. The firft cellular coat of the bladder.
Its longitudinal mufcular fibres.
789. Its other mufcular fibres.
790. The contractile power of the bladder.
791. The fecond cellular coat of the bladder.
The nervous coat.
The innermoft coat of the bladder.
The mucus of the bladder, and its fources.
792. The veffels and nerves of the bladder.
The lymphatic.
793. The bladder tranfmits and abforbs water through its inorganic pores.
794. The urine flows through the ureter into the bladder.
It remains there.
The caufes retaining the urine.
795. How the urine is expelled.
796. Various noxious matters are thrown off by the urine.
The confequences of a retention or fuppreffion of urine.
797. The urethra in general.
798. The parts receiving and fupporting the urethra.
The various capacity and figure of the urethra.
799—802. The mufcles governing the urethra.
803. The pyramidal mufcle has no effect in drawing the bladder downwards.
804. The mucus of the urethra, and its various fources.
805. The ftone in the urinary bladder.

CHAP.

CHAP. XXVII.

The MALE GENITALS.

806. The reaſon of the ſituation of the genital parts.
807. The order of the arrangement.
The various ſituations of the teſticles.
808. The ſcrotum.
The dartos.
809. The cellular texture of the ſcrotum.
The cremaſter.
810. The vaginal coat of the teſticle.
The tunica albuginea.
811. The figure and ſituation of the epididymis.
812. The ſpermatic artery.
The abdominal ring.
The courſe of the ſpermatic cord from thence to the teſticle.
The ſmall arteries to the coverings of the teſticle.
813. The diſtribution of the ſmall arteries through the teſticle.
The arteries have no anaſtomoſes with the ſpermatic vein.
The motion and quantity of the blood in the teſticle.
814. The ſpermatic vein.
815. The veſſels of the external coverings of the teſticle.
816. The nerves of the teſticle.
817. The lymphatic veſſels of the teſticle.
818. The internal ſtructure of the teſticle.
819. The ſtructure of the epididymis, and the vaſcula aberrans.
820. The motion of the ſemen.
821. The vas deferens.
822. The veſicula ſeminalis.
823. The ſemen.
824. The animalcules of the ſemen.
825. How theſe ſeem to be in the ſemen.
826. Whence the ſemen proceeds.
Of what humours it is compoſed.
What is generated in the teſticles only is prolific.
How long the ſemen is preſerved in the veſicles.
827. A part of the ſemen is abſorbed, and its effects.
How the ſemen is retained in the veſicles.
828. The quantity of ſemen.
The ſemen proceeds from the teſticle into the veſicle.
829. The proſtate gland.
Its liquor.
829.* The three dilatations of the urethra; its various directions; its coats.
830. The cavernous body of the urethra.
831. How it is proved that the blood is poured into this body.
832. The cavernous bodies of the penis.
833. The teguments of the penis.
The prepuce.
The odoriferous glands.
The ſuſpenſory ligament.
834. The uſe of the penis.
835. The erection of the penis.
Its exciting cauſes.
836. The arteries of the genital parts.
837. The veins of the ſame parts.
838. The lymphatic veſſels of the penis.
The nerves of the genital parts.
839. The immediate cauſe of the erection of the penis.
840. The expulſion of the ſemen into the urethra.
841. Its expulſion from the urethra.
This action is very violent, and almoſt convulſive.

CHAP. XXVIII.

THE VIRGIN WOMB.

842. The ſituation of the uterus in the pelvis.
How the uterus is tied to the peritonæum.
The broad ligaments.
843. The body, neck and internal mouth of the uterus.
844. The tubes of the uterus.
845. The ovaries.
846. The eggs in the ovaries.
847. The round ligament of the uterus.
848. The arteries of the uterus.
849. Its veins.
850. The internal veſſels of the uterus.
851. The lymphatic veſſels of the uterus.
852. The nerves of the uterus.
853. The age at which the menſes begin to flow.
854. The phenomena of the menſes.
The duration of the flux.
The periods at which they return.
855. The menſtrual blood flows from the veſſels of the uterus itſelf.
The nature of the menſtrual blood.
The uterus being obſtructed, the blood flows out through the vagina, and through other parts.
856. Whether the moon, ferments, or the venereal deſire, be the cauſes of the menſes.
857. The female body in general.
The pelvis and its veſſels, in as far as they differ from the fabric in the male.
How the paſſage of the blood through the uterus is thence affected.
859. The inferior limbs, pelvis, and uterus, of a female child newly born.
How the ſtructure of theſe is changed in the adult.
The effects of theſe changes.
860. Plethora is generated in both ſexes when the growth of the body ceaſes.
This, in males, goes off by the noſtrils.
In women it finds an eaſier paſſage by the uterine veſſels.
There are other effects of this determination of the blood.
How the quantity of the menſes is increaſed or diminiſhed.
861. The quantity of the blood ſent out.
The remiſſion and return of the period.
Why the period is commonly fixed to a month.
Why the menſes ceaſe to flow altogether.
Why brute animals have no menſes.
Why men want them.
862. Why the breaſts ſwell at the ſame time.

CHAP. XXIX.

CONCEPTION.

863. The difficulty of this ſubject.
The order of treating it.
864. The moſt ſimple animals of no ſex.
How they produce their young ones.
865. Oviparous animals of a ſingle ſex.
866—7. Animals

866—7. Animals of two sexes existing in the same individual.
866. What animals impregnate themselves.
867. Animals of this kind which mutually stand in need of one another's assistance.
868. Animals with two sexes divided.
869. Consequences which follow from what has been said concerning the origin and sexes of animals.
870. Causes of the venereal desire.
871. The vagina, and its situation.
The hymen.
The carunculæ myrtiformes.
872. The structure of the vagina.
873. The nymphæ.
The clitoris.
874. The constrictor muscle of the mouth of the vagina.
875. Coition.
What happens to women during the time of coition.
876. The sources of the mucous liquor ejected.
The tubes are erected in coition, and applied to the ovarium.
877—8. What changes take place in the ovarium at that time.
The corpus luteum.
878. How it is proved that the tube presses out the egg, absorbs it, and carries it to the uterus.
879. The feelings of the future mother while these things are performed.
How it is proved that conception takes place in the ovarium.
880. Why the uterus is thought to be shut after conception.
Whence the complaints after conception arise.
881. The original stamina of the new animal; whether they are from both parents, and the mixture of semen furnished from all parts of the body.
882. Whether they proceed only from the male and his seminal animalcules.
883. Whether the fœtus proceeds rather from the mother.
884. Hypotheses concerning the formation of the new animal.
885. What seems to be more certainly known concerning this matter.
886. The state of the embryo before conception.
How it is changed by the male semen.
887. Objections derived from moles, of no weight.
888. The change of the egg when brought into the uterus.
Its inosculation with the uterus.
889. The contents of the egg at that time.
The fœtus during the first days of conception.
890. The increase of the egg and of the fœtus until the placenta is completed.
Description of the completing of the placenta.
891. The placenta, and its connection with the uterus.
892. The chorion.
893. The middle membrane.
894. The amnion.
895. The umbilical vein, by which nourishment is conveyed to the fœtus.
The cord.
896. The umbilical arteries.
These, with their veins and cellular texture form the placenta.
The blood flows from the placenta into the veins of the uterus.
897. Whether the fœtus takes in the liquor of the amnion by the mouth, and is nourished by it.
What is the source of this liquor.
898. The excrements of the fœtus.
899. Whether there is any allantois in the human race.
They certainly have an urachus.
The urine is perhaps deposited in the cellular texture of the cord.
900. A compendium of the formation of the fœtus must be given.
901. What parts are formed at the very first beginning of the fœtus.

902. The proportion of the fluid to the solid parts at that time.
903. The acceſſory nutritious juices.
How the blood and reſt of the humours are perfected.
904. How the ſolid parts in general are formed.
905. The veſſels are firſt formed.
How they are produced.
906. What parts are at firſt completed and become conſpicuous in the primeval fœtus.
What are as yet involved and lie hid.
907. The motion of the heart is appended to this kind of embryo.
The heart at firſt bears the largeſt proportion to the reſt of the body.
Its pulſations are very powerful in diſtending and lengthening the veſſels.
908. What is oppoſed to this power of the heart.
How the arteries are then affected.
909. The fœtus grows very quickly.
The cauſe of this quick increaſe.
910. The embryo is altered during its growth.
910—14. By what cauſes this is chiefly produced.
910. Expanſion.
911. Attraction.
912. Preſſure.
913. The power of derivation.
Of revulſion.
914. The change of the humours.
915. How bone ſucceeds cartilage and epiphyſis.
916. How the long bones are formed.
917. How the flat bones are formed.
918. How bone is produced from gluten.
It is depoſited from the inmoſt ſubſtance of the bone, and not from the perioſteum.
919. The perioſteum.
920. The fœtus during the firſt days of pregnancy.
921. The thymus.
921—24. The circulation of the blood peculiar to the fœtus, and the organs by which it is performed.
925. Whether the fœtus breathes in the womb.
Whether it does ſo in the vagina.
926. The changes which happen to the uterus during pregnancy.
The different ſituations of the fœtus.
927. The complaints attending pregnancy.
The time of delivery.
928. Parturition.
929. The number of fœtuſes.
Superfetation.
930. The looſening of the placenta.
—of the umbilicus.
931. The contraction of the uterus after delivery.
The lochia.
The ſwelling of the breaſts.
944.* The milk.
Sympathy between the breaſts and uterus.
945. The breaſts.
Their veſſels.
Nerves.
946. The lactiferous ducts in the breaſt.
The nipple and its lactiferous ducts.
The areola of the nipple.
947. Suction.
The coloſtra.
Milk may be produced without a child.
The breaſts, after the menſes have ceaſed, become effete.
948—52. The changes which happen to the child after birth.
948. Reſpiration.
The deflexion of the courſe of the blood from the ductus arterioſus.
949. The ſhutting up of the foramen ovale.
950. The ſhutting up of the umbilical vein and ductus venoſus.
951. The contraction of the umbilical veins, and abolition of the urachus.
952. Other changes.

CHAP. XXX.

NUTRITION, GROWTH, LIFE, AND DEATH.

953. The growth of a child is flower as it advances in age.
The caufes why the growth is continually leffened.
954. The heart grows lefs in proportion than any other part of the body.
And becomes lefs irritable.
955. The end of the increafe of the body.
956. When this is faid to occur.
957. How it is proved that all parts, even the moft folid, are continually confuming and changing.
958. The caufes of the deftruction of the folid parts.
959. How the wafte of the folids is repaired.
960. How the wafte of the cellular fubftance and moft organic parts is repaired.
961. How the free extremities of parts are repaired.
962. Fatnefs.
963. The beginnings of decay.
964. The progrefs of decay.
965. The diminution of the vis infita and nervous power.
966—8. The change of the fluids.
966. The decreafe of the fluids.
967. The corruption of the fluids.
968. The increafe of the quantity of earth in the fluids.
969. Old age.
970. Decrepit old age.
971. Longevity.
972. Death from old age.
973. The figns of death.
974. The body is deftroyed by putrefaction.
The foul furvives after death, and goes to the place appointed for it by the Almighty.

FINIS.